

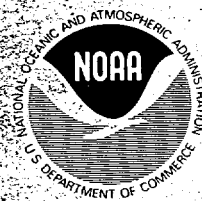
Environmental Assessment of the Alaskan Continental Shelf

Final Reports of Principal Investigators

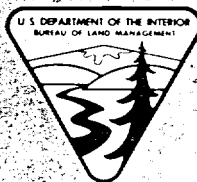
Volume 4. Biological Studies

Outer Continental Shelf Environmental Assessment Program
Boulder, Colorado

March 1979



U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration



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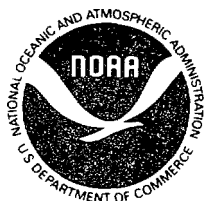
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U.S. DEPARTMENT OF COMMERCE
Juani ta M. Kreps, Secretary

National Oceanic and Atmospheric Administration
Ri chard A. Frank, Administrator

The facts, conclusions and issues appearing in these reports are based on interim results of an Alaskan environmental studies program managed by the Outer Continental Shelf Environmental Assessment Program (**OCSEAP**) of the National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce, and primarily funded by the Bureau of Land Management (**BLM**), U.S. Department of Interior, through interagency agreement.

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FINAL REPORT

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DISTRIBUTION AND ABUNDANCE OF SOME **EPIBENTHIC** INVERTEBRATES
OF THE NORTHEASTERN GULF OF ALASKA WITH NOTES ON
THE FEEDING BIOLOGY OF SELECTED SPECIES

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with

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August 1978

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I. SUMMARY OF OBJECTIVES, CONCLUSIONS, AND IMPLICATIONS
WITH RESPECT TO OCS OIL AND GAS DEVELOPMENT

The objectives of this study were to obtain: 1) a qualitative and quantitative inventory of dominant epibenthic species within the study area; 2) a description of spatial distribution patterns of selected benthic invertebrate species, and 3) preliminary observations of biological inter-relationships between selected segments of the benthic biota.

The trawl survey was effective, and excellent spatial coverage was obtained. One hundred and thirty-three (133) stations were successfully occupied yielding a mean epifaunal invertebrate biomass of 2.6 g/m². Taxonomic analysis delineated nine (9) phyla, 19 classes, 82 families, 124 genera, and 168 species of invertebrates.

Three phyla - Mollusca, Arthropoda (Crustacean), and Echinodermata - dominated in species representation with 47, 42, and 36 species taken, respectively. The same phyla dominated in biomass, with Arthropoda contributing 71.4% of the total, Echinodermata with 19%, and Mollusca with 4.6%.

The snow crab, *Chionoecetes bairdi*, contributed 66.2% of the total epifaunal invertebrate biomass. Other arthropods of significant biomass were the pink shrimp, *Pandalus borealis*, and the box crab, *Lopholithodes foraminatus*.

Important echinoderms were the brittle star, *Ophiura sarsi*, the sea stars, *Ctenodiscus crispatus* and *Pycnopodia helianthoides*, and the heart urchin, *Brisaster townsendi*.

Of the molluscs, the scallop, *Pecten caurinus*, and the snails, *Neptunea lyrata* and *Fusitriton oregonensis*, dominated.

Some areas of biological interest were identified. Stations 74-C and D, south of Hinchinbrook Entrance had a high diversity of fishes and invertebrates. Most species found here were abundant. Stations 94-A and B, located off Icy Bay, were characterized by an abundance of three species of fishes and the near absence of epifaunal invertebrates.

The highest biomass values for *Chionoecetes bairdi*, *Pandalus borealis*, *Ophiura sarsi*, and *Ctenodiscus crispatus* were recorded southeast of Kayak Island, in the vicinity of the Copper River delta. Large concentrations of fishes were also found here. The productivity of this area is thought to be

enhanced by the nutrients supplied by the Copper River and/or the presence of clockwise and counter-clockwise **gyres**.

Limited trophic interaction data were compiled during this survey. However, inferences from other Outer Continental Shelf Assessment Program (OCSEAP) investigations suggest that food groups used by the dominant north-east Gulf of Alaska (**NEGOA**) invertebrates are somewhat similar throughout their ranges.

A large number of the epifaunal species collected in the study area were either **sessile** or slow-moving forms. It is probable that many of these organisms prey upon deposit-feeding infauna as they do in the waters of Cook Inlet, Kodiak, the Bering Sea, and the southeast **Chukchi** Sea. Many of these epifaunal species would be affected by oil spills either because of their inability to leave the area or as a result of their food dependence on **deposit-feeding** species that incorporate sediment in the feeding process. Experimentation on toxic effects of oil on snow crabs, king crabs and pandalid shrimps have been carried out by other investigators.

Initial assessment of the data suggests that a few unique, abundant, and/or large benthic species (snow crabs, shrimps, brittle stars, sea stars) are characteristic of the areas investigated and that these species may represent organisms that could be useful for monitoring purposes. Two biological parameters that should be addressed in conjunction with **petroleum-related** activities are feeding and reproductive biology of important species. It is suggested that an intensive program designed to examine these parameters be initiated well in advance on industrial activity in the oil lease areas.

II. INTRODUCTION

General Nature and Scope of Study

The operations connected with oil exploration, production, and transportation in the northeast Gulf of Alaska (**NEGOA**) will present a wide spectrum of potential dangers to the marine environment (see Olson and Burgess, 1967; and Malins, 1977, for general discussion of marine pollution problems). Adverse effects on the marine environment cannot be **quantitatively** assessed, or even predicted, unless background data are recorded prior to industrial development. Insufficient long-term information about an environment, and

the basic biology of species in that environment, can lead to erroneous interpretations of changes in species composition and abundance that might occur if the area becomes altered by industrial activity (see Baker, 1976; Nelson-Smith, 1973; Pearson, 1971, 1972, 1975; Rosenberg, 1973, for general discussions on **benthic** biological investigations in industrialized marine areas) . Populations of marine species fluctuate over a time span of a few to 30 years (Lewis, 1970, and personal communications), but such fluctuations are typically unexplainable because of absence of long-term data (Lewis, 1970).

Benthic invertebrates (primarily the infauna but also sessile and slow-moving **epifauna**) are useful as indicator species for a disturbed area because they tend to remain in place, typically react to long-range environmental changes, and, by their presence, generally reflect the nature of the substratum. Consequently, organisms of the infaunal benthos have frequently been chosen to monitor long-term pollution effects, and are believed to reflect the biological health of a marine area (see Pearson, 1971, 1972, 1975; and Rosenberg, 1973, for discussion on long-term usage of **benthic** organisms for monitoring pollution). The presence of large numbers of **benthic epifaunal** species of actual or potential commercial importance (crabs, shrimps, snails, fin fishes) in NEGOA further dictates the necessity of understanding **benthic** communities since many commercially important species feed on **infaunal** and small **epifaunal** residents of the benthos (see Zenkevitch, 1963; and Feder, 1977a, 1978a; and Feder *et al.*, 1978; Feder and Jewett, 1977a, b) for discussions of the interaction of commercially important species and the **benthos**). Any drastic changes in density of the food **benthos** could affect the health and numbers of these economically important species.

Experience in pollution-prone areas of England (Baker, 1976; Smith, 1968), Scotland (Pearson, 1972, 1975), and California (Straughan, 1971) suggests that at the completion of an exploratory study, selected stations should be examined regularly on a long-term basis to monitor species content, diversity, abundance and biomass. Such long-term data acquisition in NEGOA should make it possible to differentiate between normal *ecosystem* variation and pollutant-induced alteration. Furthermore, intensive investigation of the

food habits of benthic species of NEGOA are also essential in order to understand trophic interactions there and to predict changes that might take place once oil-related activities are initiated.

The intensive trawl study considered in this report delineates the major epifauna on the northeastern Gulf of Alaska shelf. The information obtained on faunal composition and abundance in this investigation now represents a general data base to which future changes can be compared. A major portion of this data is presented in Jewett and Feder (1976). Long-term studies on life histories and trophic interactions should ultimately define functional aspects of communities and ecosystems vulnerable to environmental damage, and should help determine rates at which damaged environments can recover.

Relevance to Problems of Petroleum Development

Lack of adequate data on a world-wide basis makes it difficult to predict the effects of oil-related activity on the subtidal benthos. However, the recent expansion of research activities in NEGOA should ultimately enable us to point with some confidence to certain species or areas there that might bear closer scrutiny once industrial activity is initiated. It must again be emphasized that a broad time frame is needed to comprehend long-term fluctuations in composition and density of benthic species; thus, it cannot be expected that short-term research programs will result in adequate predictive capabilities. Assessment of any ecological system must always be a continuing endeavour.

As indicated above, infaunal species tend to remain in place and, consequently, have been useful as indicator species for disturbed areas. Thus, close examination of stations with substantial complements of infaunal species is warranted (see Feder and Matheke, in press, for comments on infaunal benthos). Changes in the environment at these and other stations with a relatively large number of species might be reflected in a decrease in diversity of species with increased dominance of a few (see Nelson-Smith, 1973, for further discussion of oil-related changes in diversity). Likewise, stations with substantial numbers of epifaunal species should be assessed on a continuing basis. The effect of loss or reduced numbers of specific epifaunal species to the

overall **trophic** structure in NEGOA can be conjectured on the basis of available food studies (Feder, 1977a; Feder and Jewett, 1977a,b; Smith *et al.*, 1978; Feder, 1978a; Jewett, in press; Paul *et al.*, in press).

Data indicating the effect of oil on **subtidal benthic** invertebrates are fragmentary (Nelson-Smith, 1973; Boesch *et al.*, 1974; Malins, 1977), but it is known that echinoderms are "notoriously sensitive to any reduction in water quality" (Nelson-Smith, 1973). Echinoderms (**ophiuroids**: brittle stars; **asteroids**: sea stars; **holothuroids**: sea cucumbers) are conspicuous members of the benthos of NEGOA and could be affected by oil activities there. Two echinoderm groups, asteroids and ophiuroids, are often components of the diet of large crabs (Cunningham, 1969; Feder, 1977a; Feder, 1978b; G. Powell, ADF&G, pers. comm.) and a few species of **demersal** fishes (Smith *et al.*, 1978; Wigley and Theroux, 1965).

King crabs (*Paralithodes camtschatica*), snow crabs (*Chionoecetes bairdi*) and pandalid shrimps (e.g. *Pandalus borealis*) are conspicuous members of the shallow shelf of NEGOA and support commercial fisheries of considerable importance there. The effects of Cook Inlet crude oil water soluble fractions on the survival and molting of king crab and coonstripe shrimp (*Pandalus hypsinotus*) larvae were examined by Mecklenburg *et al.* (1976). Low concentrations (<0.54 ppm) of oil produced a moribund condition (cessation of swimming) in all larval stages and ultimately caused death. Molting of both species was permanently inhibited by exposing larvae for 72 hours at crude oil concentration of 0.8 to 0.9 ppm. Larvae that failed to molt, died in seven days. Laboratory experiments with **postlarval** *C. bairdi* have shown that **postmolt** individuals lose most of their legs after exposure to Prudhoe Bay crude oil (Karinen and Rice, 1974).

Little other direct data based on laboratory experiments are available for **subtidal benthic** species (see Nelson-Smith, 1973). Thus, experimentation on toxic effects of oil on other common members of the **subtidal benthos** should be strongly encouraged in future Outer Continental Shelf (OCS) programs.

A direct relationship between **trophic** structure (feeding type) and bottom stability has been demonstrated (Rhoads, 1974). A diesel fuel spill resulted in oil becoming adsorbed on sediment particles with the resultant mortality of many deposit feeders living on sublittoral muds. Bottom stability was altered

with the death of these organisms, and a new complex of species became established in the altered substratum. Many NEGOA infaunal species are deposit feeders; thus, oil-related mortality of these species could likewise result in a changed near-bottom sedimentary regime with subsequent alteration of species composition. An understanding of these species as well as epifaunal organisms and their interactions with each other is essential to the development of predictive capabilities required for the NEGOA outer continental shelf.

III. CURRENT STATE OF KNOWLEDGE

Little was known about the biology of the invertebrate benthos of the northeast Gulf of Alaska (NEGOA) at the time that Outer Continental Shelf Environmental Assessment Program (OCSEAP) studies were initiated there, although a compilation of some relevant data on the Gulf of Alaska was available (Rosenberg, 1972). A short but intensive survey in the summer of 1975 added some benthic biological data for a specific area south of the Bering Glacier (Bakus and Chamberlain, 1975). Results of the latter ongoing study are similar to those reported by Feder and Mueller (1975) in their OCSEAP investigation. Some scattered data based on trawl surveys by the Bureau of Commercial Fisheries (now National Marine Fisheries Service) were available, but much of the information on the invertebrate fauna was so general as to have little value.

In the summer and fall of 1961 and spring of 1962 otter trawls were used to survey the shellfishes and bottomfishes on the continental shelf and upper continental slope in the Gulf of Alaska (Hitz and Rathjen, 1965). The surveys were part of a long-range program begun in 1950 to determine the size of bottomfish stocks in the northeastern Pacific Ocean between southern Oregon and northwest Alaska. Invertebrates taken in the trawls were of secondary interest, and only major groups and/or species were recorded. Invertebrates that comprised 27 percent of the total catch were grouped into eight categories; heart urchins (Echinodermata:Echinoidea), snow crab (*Chionoecetes bairdi*), sea stars (Echinodermata :Asteroidea), Dungeness crab (*Cancer magister*), scallop (*Pecten caurinus*), shrimps (*Pandalus borealis*, *P. platyceros*, and *Pandalopsis dispar*), king crab (*Paralithodes camtschatica*), and miscellaneous invertebrates (shells, sponges, etc.) (Hitz and Rathjen,

1965) . Heart urchins accounted for about 50% of the invertebrate catch and snow crab ranked second, representing about 22%. Approximately 20% of the total invertebrate catch was composed of sea stars.

Further knowledge of invertebrate stocks in the north Pacific is scant. The International Pacific Halibut Commission (IPHC) surveys parts of the Gulf of Alaska annually and records selected commercially important invertebrates; however, non-commercial species are discarded. The **benthic** investigations of Feder and **Mueller** (1975), Feder (1977a), and this report represent the first broad-based qualitative and quantitative examinations of the **benthic** infauna and epifauna on the shelf of the Gulf of Alaska. **Ronholt et al.** (1976), review the history of commercial fisheries in the northeast Gulf of Alaska, and give data from fishing activities there.

Information in the literature has uncovered data that will aid in the interpretation of the biology of some dominant organisms in the Gulf of Alaska (see Feder, 1977b).

Examination of **trophic** relationships of selected **infaunal** and **epifaunal** species was initiated in 1976 as a part of the lower Cook Inlet and Kodiak investigations (**Feder**, 1977a; Feder and Jewett, 1977a). Food studies by Smith *et al.* (1978) and the present report will contribute to an understanding of trophic relationship in NEGOA.

IV. STUDY AREA

One hundred and forty (140) stations were occupied in conjunction with the National Marine Fisheries Service Resource Assessment trawl survey (**Ronholt et al.**, 1976) which sampled a grid extending from the western tip of Montague Island (148°W Longitude) to Yakutat Bay (140°W Longitude) (Fig. 1). Samples were taken to a maximum depth of approximately 500 meters (274 fathoms).

v. SOURCES, METHODS, AND RATIONAL OF DATA COLLECTION

Epifauna was collected onboard the M/V *North Pacific* in the northeastern Gulf of Alaska (NEGOA) from April 25 to August 7, 1975. One-hour tows (a standard tow) were made at predetermined stations (Fig. 1) using a commercial sized 400-mesh Eastern otter trawl with a 12.2 meter horizontal opening. All

Figure 1. Station grid established for the trawl survey on the continental shelf of the northeastern Gulf of Alaska (NEGOA), summer 1975.

invertebrates currently of non-commercial importance were sorted on shipboard, given tentative identifications, counted, weighed, and aliquot samples preserved and labeled for final identification at the Institute of Marine Science, University of Alaska. Hermit crab weights included shell weights. Counts and weights of commercially important invertebrate species were recorded by National Marine Fisheries Service personnel, and the data made available to the benthic invertebrate program.

Biomass per unit area (g/m^2) was calculated as follows:

$\frac{w}{Tw(Dx1000)}$, where w = weight (grams), Tw = width of trawl opening (meters), and $(Dx1000)$ = distance fished (kilometers x 1000). The data basis for all calculations of biomass per m^2 are included with the station data submitted to the National Oceanographic Data Center (NODC). Data from selected stations are included in the Appendix.

When laboratory examination revealed more than a single species in a field identification, the counts and weights of the species in question were arbitrarily expanded from the laboratory species ratio to encompass the entire catch of the trawl.

Limited feeding data was obtained and recorded whenever time permitted. The frequency of occurrence method was used.

VI. RESULTS

Distribution, Abundance, and Biomass

The benthic trawl program in the northeast Gulf of Alaska (NEGOA) permitted the successful occupation of 133 stations. A distance of 732.24 kilometers (km) were fished ($8,933,328 \text{ m}^2$) in 127.43 hours of trawling. The total epifaunal invertebrate biomass collected was 23,447.8 kilograms (kg), yielding a mean of 2.6 g/m^2 .

Taxonomic analysis delineated nine (9) phyla, 19 classes, 82 families, 124 genera, and 168 species of invertebrates. Three phyla, Mollusca, Arthropoda (Crustacean), and Echinodermata, dominated in species representation with 47, 42, and 36 species taken, respectively (Tables I and II).

The same phyla dominated in biomass also, with Arthropoda contributing 71.4% of the total, Echinodermata with 19.0%, and Mollusca with 4.6% (Tables II and III).

TABLE I

INVERTEBRATES TAKEN BY TRAWL FROM THE NORTHEAST GULF
OF ALASKA (NEGOA) ON BOARD THE M/V *NORTH PACIFIC*

Phylum Porifera	
	unidentified species
Phylum Cnidaria	
Class Hydrozoa	
	unidentified species
Class Scyphozoa	
Family Pelagiidae	
	<i>Chrysaora melanaster</i> Brandt
Class Anthozoa	
Subclass Alcyonaria	
	<i>Eunephthya rubiformis</i> (Pallas)
Family Primnoidae	
	<i>Stylatula gracile</i> (Gabb)
Family Pennatulidae	
	<i>Ptilosarcus gurneyi</i> (Gray)
Family Actiniidae	
	<i>Tealia crassicornis</i> (O. F. Müller)
Phylum Annelida	
Class Polychaeta	
Family Polynoidae	
	<i>Arctonoe vittata</i> (Grube)
	<i>Eunoe depressa</i> Moore
	<i>Eunoe oerstedii</i> Malmgren
	<i>Harmothoe multisetosa</i> Moore
	<i>Hololepida magna</i> Moore
	<i>Lepidonotus squamatus</i> (Linnaeus)
	<i>Lepidonotus</i> sp.
	<i>Polyeunoa tutu</i> (Grube)
Family Polynodontidae	
	<i>Peisidice aspera</i> Johnson
Family Euphrosinidae	
	<i>Euphrosine hortensis</i> Moore
Family Syllidae	
	unidentified species
Family Nereidae	
	<i>Ceratonereis paucidentata</i> (Moore)
	<i>Ceratonereis</i> sp.
	<i>Cheilonereis cyclurus</i> (Barrington)
	<i>Nereis pelagica</i> Linnaeus
	<i>Nereis vexillosa</i> Grube
	<i>Nereis</i> sp.
Family Nephtyidae	
	unidentified species
Family Glyceride	
	<i>Glycera</i> sp.

TABLE I

CONTINUED

-
- Family Eunicidae
 - Eunice valens* (Chamberlain)
 - Family Lumbrineridae
 - Lumbrineris similabris* (Treadwell)
 - Family Opheliidae
 - Travisia pupa* Moore
 - Family Sabellariidae
 - Idanthyrus armatus* Kinberg
 - Family Terebellidae
 - Amphitrite cirrata* O. F. Müller
 - Family Sabellidae
 - Euchone analis* (Kröyer)
 - Family Serpulidae
 - Crucigera* irregulars Bush
 - Family Aphroditidae
 - Aphrodita japonica* Marenzeller
 - Aphrodita negligens* Moore
 - Aphrodita* sp.
 - Class Hirudinea
 - Notostomobdella* sp.

Phylum Mollusca

- Class Polyplacophora
 - Family Mopaliidae
 - unidentified species
- Class Pelecypoda
 - Family Nuculanidae
 - Nuculana fossa* Baird
 - Family Mytilidae
 - Mytilus edulis* Linnaeus
 - Musculus niger* (Gray)
 - Modiolus modiolus* (Linnaeus)
 - Family Pectinidae
 - Chlamys hastata hericia* (Gould)
 - Pecten caurinus* Gould
 - Delectopecten randolphi* (Dan)
 - Family Astartidae
 - Astarte polaris* Dan
 - Family Carditidae
 - Cyclocardia ventricosa* (Gould)
 - Family Cardiidae
 - Clinocardium ciliatum* (Fabricius)
 - Clinocardium fucanum* (Dan)
 - Serripes groenlandicus* (Bruguère)
 - Family Veneridae
 - Compsomya subdiaphana* Carpenter
 - Family Mactridae
 - Spisula polynyma* (Stimpson)

TABLE I
CONTINUED

Family Myidae	unidentified species
Family Hiatellidae	<i>Hiatella arctica</i> (Linnaeus)
Family Teredinidae	<i>Bankia setacea</i> Tryon
Family Lyonsiidae	unidentified species
Class Gastropoda	
Family Bathybembix	<i>Solariella obscura</i> (Couthouy)
	<i>Lischkeia cidaris</i> (Carpenter)
Family Naticidae	<i>Natica clausa</i> Broderip and Sowerby
	<i>Polinices monteronus</i> Dall
	<i>Polinices lewisii</i> (Gould)
Family Cymatiidae	<i>Fusitriton oregonensis</i> (Redfield)
Family Muricidae	<i>Trophonopsis stuarti</i> (Smith)
Family Buccinidae	<i>Buccinum plectrum</i> Stimpson
	<i>Beringius kennicotti</i> (Dan)
	<i>Colus halli</i> (Dan)
	<i>Morrisonella pacifica</i> (Dan)
	<i>Neptunea lyrata</i> (Gmelin)
	<i>Neptunea pribiloffensis</i> (Dan)
	<i>Plicifusus</i> sp.
	<i>Pyrulofusus harpa</i> (Mörch)
	<i>Volutopsius filiosus</i> Dall
Family Columbelloidae	<i>Mitrella gouldi</i> (Carpenter)
Family Volutidae	<i>Arctomelon stearnsii</i> (Dan)
Family Turridae	<i>Oenopota</i> sp.
	<i>Aforia circinata</i> (Dan)
Family Dorididae	unidentified species
Family Tritoniidae	<i>Tritonia exsulans</i> Bergh
	<i>Tochuina tetraquetra</i> (Pallas)
Family Flabellinidae	<i>Flabellinopsis</i> sp.
Class Cephalopoda	
Family Sepiolidae	<i>Rossia pacifica</i> Berry

TABLE I

CONTINUED

-
- Family **Gonatidae**
Gonatopsis borealis Sasaki
Gonatus magister Berry
- Family **Octopodidae**
octopus Sp.
- Phylum **Arthropoda**
Class **Crustacea**
Order **Thoracica**
Family **Lepadidae**
Lepas pectinata pacifica Henry
- Family **Balanidae**
Balanus hesperius
Balanus rostratus Hock
Balanus sp.
- Order **Isopoda**
Family **Aegidae**
Rocinela augustata Richardson
- Family **Bopyridae**
Argeia pugettensis Data
- Order **Decapoda**
Family **Pandalidae**
Pandalus borealis Kröyer
Pandalus jordani Rathbun
Pandazus montagui tridens Rathbun
pandazus platyceros Brandt
Pandalus hypsinotus Brandt
Pandalopsis dispar Rathbun
- Family **Hippolytidae**
Spirontocaris lamellicornis (Dana)
Spirontocaris arcuata Rathbun
Eualus barbata (Rathbun)
Eualus macrophthalma (Rathbun)
Eualus suckleyi (Stimpson)
Eualus pusiola (Kröyer)
- Family **Crangonidae**
Crangon communis Rathbun
Argis sp.
Argis dentata (Rathbun)
Argis ovifer (Rathbun)
Argis alaskensis (Kingsley)
Paracrangonechinata Dana
- Family **Paguridae**
Pagurus ochotensis (Benedict)
Pagurus aleuticus (Benedict)
Pagurus kennerlyi (Stimpson)
Pagurus confragosus (Benedict)
Elassochirus tenuimanus (Dana)
Elassochirus cavimanus (Miers)

TABLE I

CONTINUED

	<i>Labidochirus splendescens</i> (Owen)
Family Lithodidae	
	<i>Acantholithodes hispidus</i> (Stimpson)
	<i>Paralithodes camtschatica</i> (Tilesius)
	<i>Lopholithodes foraminatus</i> (Stimpson)
	<i>Rhinolithodes vosnessenskii</i> Brandt
Family Galatheidae	
	<i>Munida quadrispina</i> Benedict
Family Majiidae	
	<i>Oregonia gracilis</i> Dana
	<i>Hyas lyratus</i> Dana
	<i>Chionoecetes bairdi</i> Rathbun
	<i>Chorilia longipes</i> Dana
Family Cancridae	
	<i>Cancer magister</i> Dana
	<i>Cancer oregonensis</i> (Dana)
Phylum Ectoprocta	
	unidentified species
Phylum Brachiopoda	
Class Articulate	
Family Cancellothyrididae	
	<i>Terebratulina unguicula</i> Carpenter
Family Dallinidae	
	<i>Laqueus californianus</i> Koch
	<i>Terebratalia transversa</i> (Sowerby)
Phylum Echinodermata	
Class Asteroidea	
Family Asteropidae	
	<i>Dermasterias imbricata</i> (Grube)
Family Astropectinidae	
	<i>Dipsacaster borealis</i> Fisher
Family Benthoplectinidae	
	<i>Luidiaster dawsoni</i> (Verrill)
	<i>Nearchaster pedicellaris</i> (Fisher)
Family Goniasteridae	
	<i>Ceramaster patagonicus</i> (Sladen)
	<i>Hippasterias spinosa</i> Verrill
	<i>Mediaster aequalis</i> Stimpson
	<i>Pseudarchaster parelii</i> (Düben and Koren)
Family Luididae	
	<i>Luidia foliolata</i> Grube
Family Porcellanasteridae	
	<i>Ctenodiscus crispatus</i> (Retzius)
Family Echinasteridae	
	<i>Henricia aspera</i> Fisher
	<i>Henricia</i> sp.
	<i>Poraniopsis inflata</i> Fisher

TABLE I

CONTINUED

Family Pterasteridae	
<i>Diplopteraster multipes</i> (Sars)	
<i>Pteraster tessellatus</i>	
Family Solasteridae	
<i>Crossaster borealis</i> (Fisher)	
<i>Crossaster papposus</i> (Linnaeus)	
<i>Lophaster furcilliger</i> Fisher	
<i>Lophaster furcilliger vexator</i> Fisher	
<i>Solaster dawsoni</i> Verrill	
Family Asteridae	
<i>Leptasterias</i> sp.	
<i>Lethasterias nanimensis</i> (Verrill)	
<i>Stylasterias forreri</i> (de Loriol)	
<i>Pycnopodia helianthoides</i> (Brandt)	
Class Echinoidea	
Family Schizasteridae	
<i>Brisaster townsendi</i>	
Family Strongylocentrotidae	
<i>Allocentrotus fragilis</i> (Jackson)	
<i>Strongylocentrotus droebachiensis</i> (O. F. Müller)	
Class Ophiuroidea	
Family Amphiuridae	
<i>Unioplus macraspis</i> (Clark)	
Family Gorgonocephalidae	
<i>Gorgonocephalus caryi</i> (Lyman)	
Family Ophiactidae	
<i>Ophiopholis aculeata</i> (Linnaeus)	
Family Ophiuridae	
<i>Amphiophiura ponderosa</i> (Lyman)	
<i>Ophiura sarsi</i> Liitkin	
Class Holothuroidea	
Family Molpadiidae	
<i>Molpadia</i> sp.	
Family Cucumariidae	
unidentified species	
Family Psolidae	
<i>Psolus chitinoides</i> H. L. Clark	
Class Crinoidea	
unidentified species	
Phylum Chordata	
Class Phlebobranchia	
Family Rhodosomatiidae	
<i>Chelyosoma columbianum</i> Huntsman	
Class Stolidobranchia	
Family Pyuridae	
<i>Halocynthia helgendorfi igaboja</i> Oka	

TABLE II
MISCELLANEOUS DATA FOR INVERTEBRATES COLLECTED BY
COMMERCIAL TRAWL IN THE NORTHEAST GULF OF ALASKA
(NEGOA) ON THE M/V NORTH PACIFIC

Phylum	Number of Species	% of Species	Wt (kg)	% Total Wt
Mollusca	47	28.0	1089.2	4.6
Arthropoda (Crustacea)	42	25.0	16748.6	71.4
Echinodermata	36	21.4	4462.0	19.0
Annelida	30	17.8	2.8	<0.1
Cnidaria	6	3.6	513.4	2.2
Brachiopoda	3	1.8	49.8	0.2
Chordata (Tunicata)	2	1.2	322.2	1.4
Ectoprocta	1	0.6	3.7	<0.1
Porifera	1	0.6	256.2	1.0
TOTAL	168	100.0%	23,447.9	100.0%

Phylum	Subgroup	Wt (kg)	% of Phylum Wt	% Total Wt
Arthropoda	Decapoda	16692.60	99.7%	71.4%
Echinodermata	Asteroidea	1575.99	35.3%	6.7%
	Ophiuroidea	1492.81	33.5%	6.4%
	Holothuroidea	709.60	15.9%	3.0%
	Echinoidea	644.15	14.4%	2.7%
Mollusca	Gastropoda	557.70	51.2%	2.4%
	Pelecypoda	488.36	44.8%	2.1%
	Cephalopoda	36.91	3.4%	0.1%

TABLE III

PERCENTAGE COMPOSITION BY WEIGHT OF LEADING INVERTEBRATE
SPECIES COLLECTED DURING NORTHEAST GULF OF
ALASKA (NEGOA) TRAWLING INVESTIGATIONS

Phyla	Percentage of Total Weight	Leading Species	Average Weight per Individual	Percentage Weight within Phylum	Percentage Weight from all Phyla
Arthropoda	71.4	<i>Chionoecetes bairdi</i>	454 g	92.6	66.2
		<i>Pandalus borealis</i>	8 g	4.0	2.9
		<i>Lopholithodes foraminatus</i>	420 g	0.6	0.4
				Total	97.2
					69.5
Echinodermata	19.0	<i>Ophiura sarsi</i>	6 g	23.2	4.4
		<i>Ctenodiscus crispatus</i>	10 g	15.7	2.9
		<i>Brisaster townsendi</i>	10 g	11.2	2.1
		<i>Pycnopodia helianthoides</i>	482 g	10.3	2.0
				Total	60.4
Mollusca	4.6	<i>Pecten caurinus</i>	350 g	43.4	2.0
		<i>Neptunea lyrata</i>	180 g	12.5	0.6
		<i>Fusitriton oregonensis</i>	100 g	11.5	0.5
				Total	67.4
Total	95.0				3.1

Of the crustaceans, the families Majidae, Pandalidae, and Lithodidae were most important in terms of biomass. The snow crab (*Chionoecetes bairdi*) of the family Majidae contributed 66.2% of the total epifaunal invertebrate biomass and 92.6% of the arthropod biomass (Table III). This species was widely distributed over the area sampled, with the greatest density found at Station 82-A¹ (see Appendix) where 892 kg of *Chionoecetes bairdi* (1984 individuals) were taken in a standard tow, or 19.8 g/m² (Fig. 2). The mean catch per unit effort (CPUE) of the snow crab was 122 kg/hr (268 lbs/hr).

The pink shrimp (*Pandalus borealis*) was also widespread, and accounted for 2.9% of the total invertebrate biomass (Table III). The highest biomass was taken at Station 83-C with 2.4 g/m² or 167.7 kg (370 lbs) taken in a standard tow (Fig. 3). The mean CPUE was 5.3 kg/hr (11.7 lbs/hr).

Of the lithode crabs, the box crab (*Lopholithodes foraminatus*) was most abundant. This crab was the third most important crustacean in terms of weight (Table III). The greatest density was found at Station 86-D, where 55 of these crabs weighed 25.4 kg (56 lbs), the equivalent of 0.3 g/m² (Fig. 4). The average CPUE of *L. foraminatus* was 0.19 kg/hr (2 lbs/hr).

Four echinoderm species, a brittle star (*Ophiura sarsi*), two sea stars (*Ctenodiscus crispatus* and *Pycnopodia helianthoides*), and the heart urchin (*Brisaster townsendi*) were found in large quantities (Table III). The percent-weight composition of sea stars as a percentage of all echinoderms and all invertebrates was 35.3% and 6.7% respectively (Table II). Brittle stars (Ophiuroidea) were the second largest class of echinoderms collected, accounting for 33.5% of the echinoderm biomass and 6.4% of the total invertebrate biomass (Table II). Sea cucumbers (Holothuroidea), and sea urchins and sand dollars (Echinoidea) comprised 15.9% and 14.4% of the echinoderm biomass, respectively (Table II). *Ophiura sarsi* was the most abundant echinoderm comprising 23.2% of the total echinoderm biomass and 4.4% of the total invertebrate biomass. The largest catch of this brittle star, at Station 81-D, was 750 kg (1653 lbs) in an hour tow, equivalent to 11.4 g/m² (Fig. 5). Average CPUE was 8.1 kg/hr (18 lbs/hr). Greatest biomass for the small sea star *Ctenodiscus crispatus* was found at Station 80-B, with 0.8 g/m² or 55.8 kg

¹The data from fourteen stations (74-C, 74-D, 80-B, 81-D, 82-A, 83-C, 83-E, 86-D, 89-A, 93-C, 94-A, 94-B, 97-C, 99-D) referred to in the text are compiled separately in the Appendix.

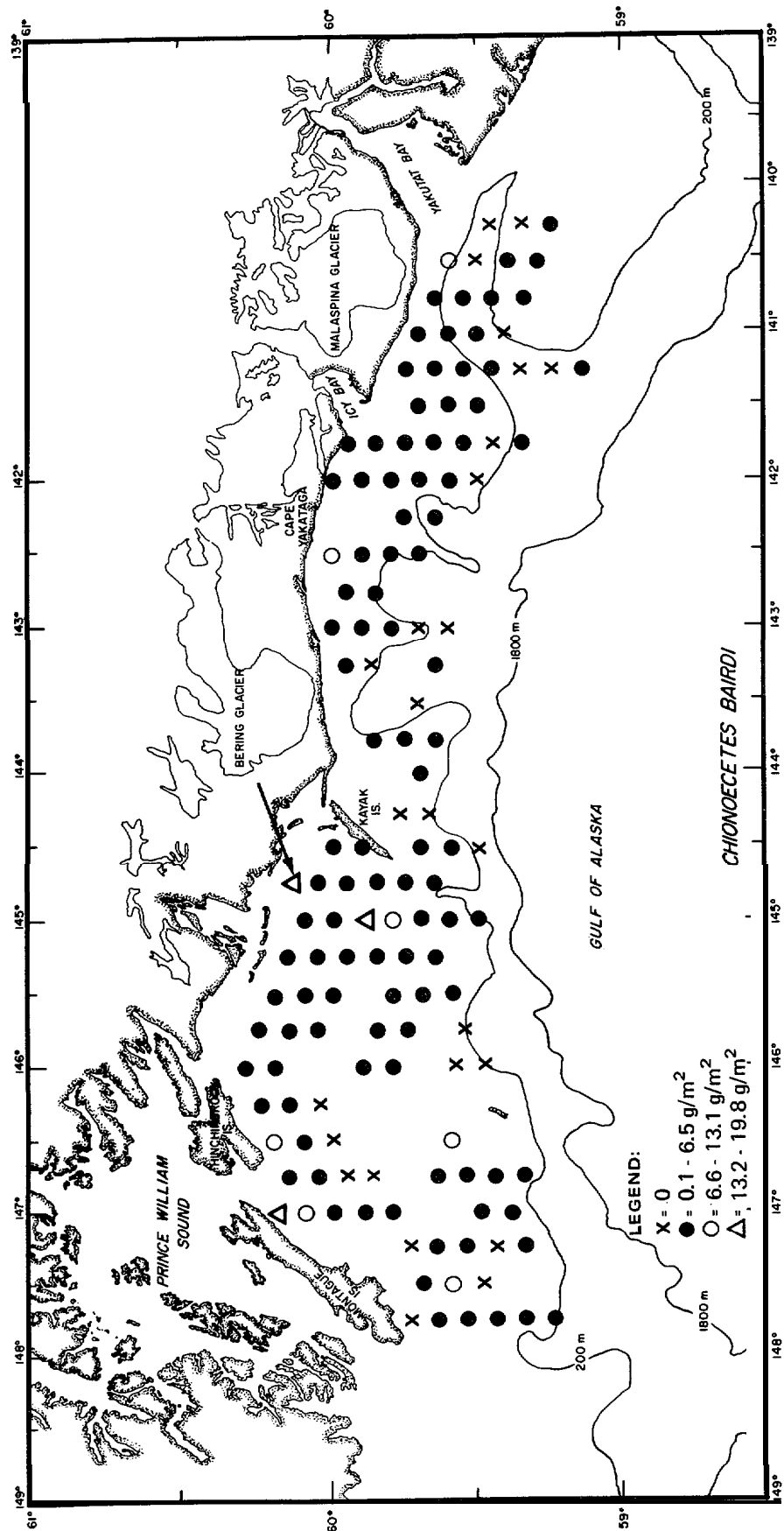


Figure 2. Distribution and abundance of the snow crab, *Chionoecetes bairdi*, from the northeastern Gulf of Alaska (NEGOA) trawl survey, summer 1975. Arrow indicates highest density of *C. bairdi*.

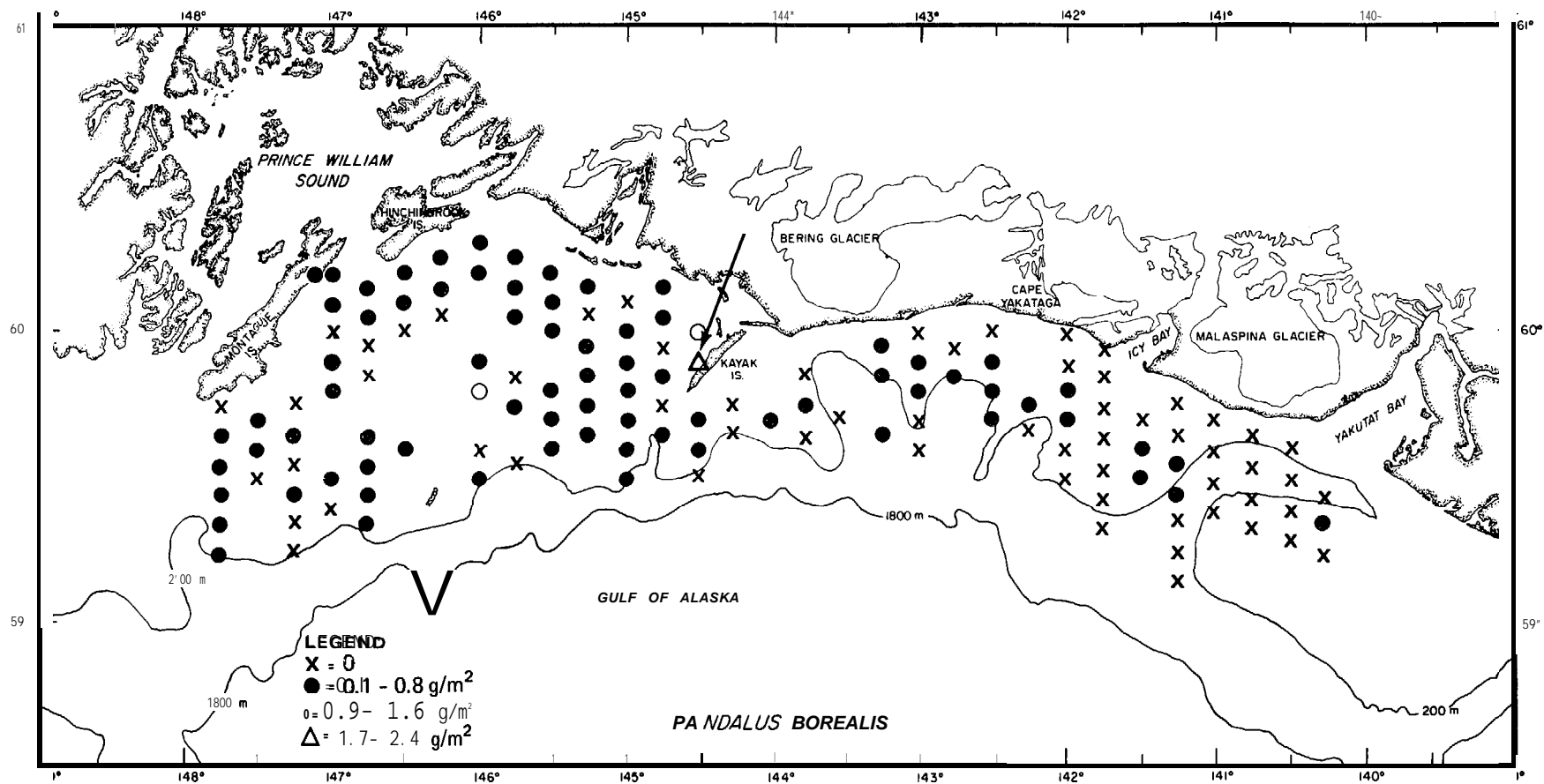


Figure 3. Distribution and abundance of the pink shrimp, *Pandalus borealis*, from the northeastern Gulf of Alaska (NEGOA) trawl survey, summer 1975. Arrow indicates highest density of *P. borealis*.

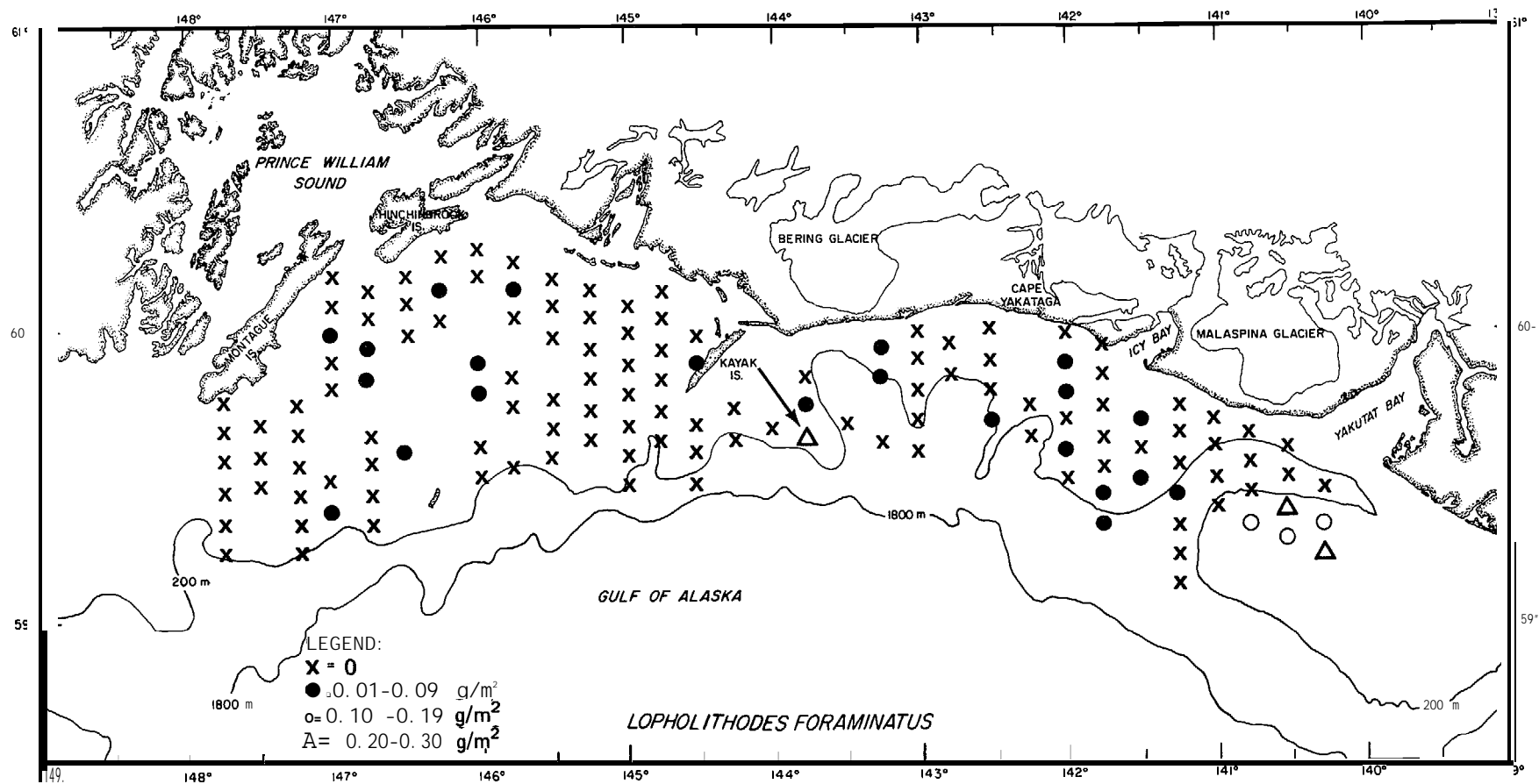


Figure 4. Distribution and abundance of the box crab, *Lopholithodes foraminatus*, from the north-eastern Gulf of Alaska (NEGOA) trawl survey, summer 1975. Arrow indicates highest density of *L. foraminatus*.

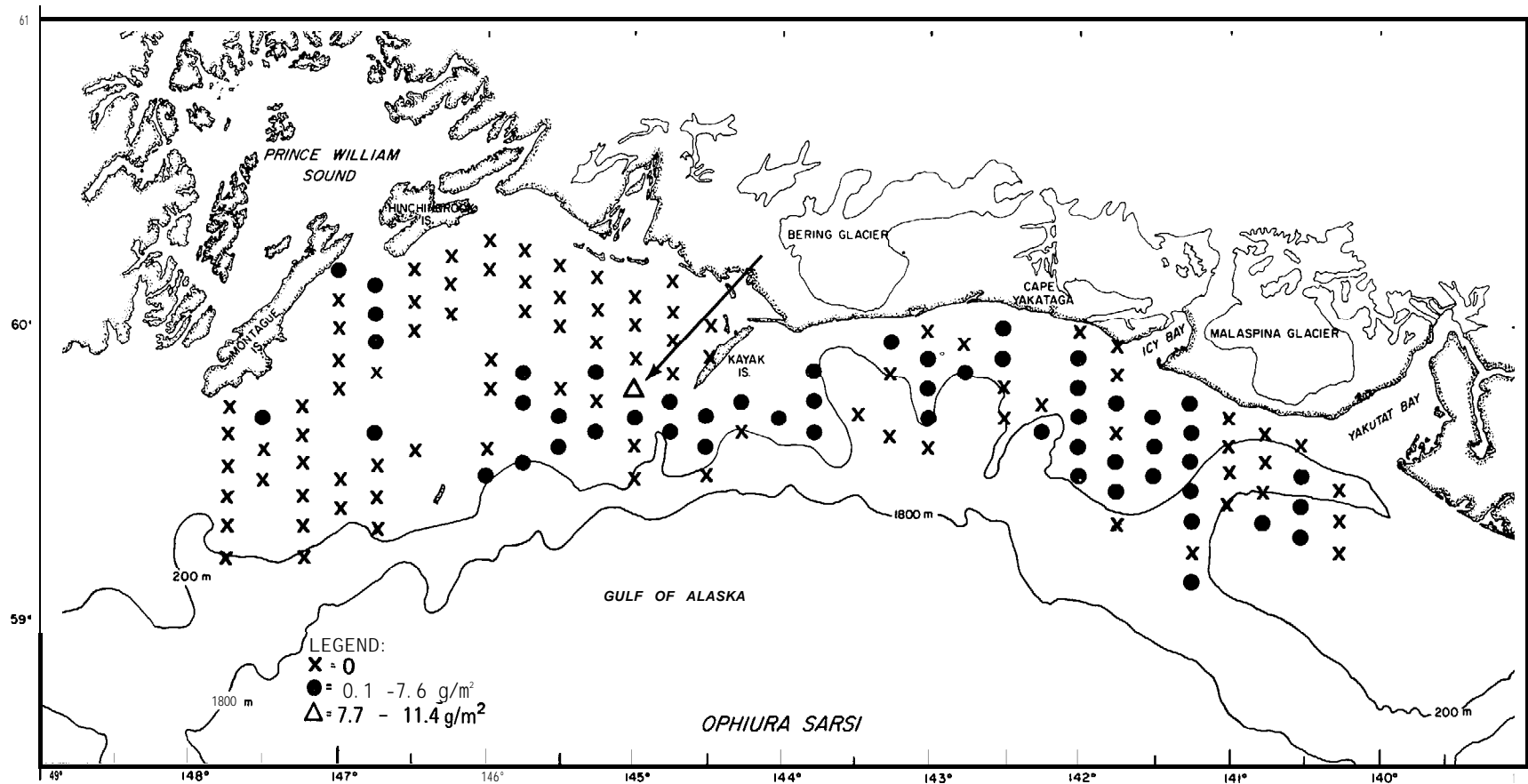


Figure 5. Distribution and abundance of the brittle star, *Ophiura sarsi*, from the northeastern Gulf of Alaska (NEGOA) trawl survey, summer 1975. Arrow indicates highest density of *O. sarsi*.

(123 lbs) taken per hour (Fig. 6). The average CPUE of this species was 5.5 kg/hr (12 lbs/hr). *Pycnopodia helianthoides* was another widely distributed sea star. One hundred and seventy of these large sea stars (average weight 0.453 kg) were taken at Station 93-C (Fig. 7). At this station the biomass of *Pycnopodia* was 1.3 g/m² or 85.5 (188 lbs) taken per hour. The average CPUE was 3.6 kg/hr (8 lbs/hr). The heart urchin *Brisaster townsendi* accounted for approximately 11% of the echinoderm biomass taken in the trawl survey (Table 111). Station 97-C yielded the largest catch of this urchin with 2.9 g/m² or 213 kg (469 lbs) per hour; this represented 21,272 urchins collected during the tow (Fig. 8). The average CPUE was 3.9 kg/hr (8.6 lbs/hr).

Although sea cucumbers (family Cucumariidae) were found at only seven stations, they ranked high in echinoderm weight composition. For example, the tow at Station 99-D contained approximately 2600 of these holothuroids weighing 650 kg (1433 lbs), equivalent to 9.6 g/m² (Fig. 9). The average CPUE was 5.3 kg/hr (11.6 lbs/hr).

Of the 47 species of molluscs collected, the scallop *Pecten* (= *Patinopecten*) *caurinus* was dominant. This large bivalve accounted for two percent of the total epifaunal invertebrate biomass, and 43% of the molluscan biomass (Table III). Station 83-E provided the largest catch of scallops with 1.7 g/m² or 116 kg (370 lbs) per standard tow (Fig. 10). The average CPUE was 3.7 kg/hr (8 lbs/hr).

Snails of the family Buccinidae were the dominant gastropod in the NEGOA area. *Neptunea lyrata* was the most abundant, with the greatest biomass being taken at Station 89-A (Fig. 11). Here, 32.4 kg/hr (71 lb/hr) or 0.4 g/m² were taken. The average CPUE for this snail was 1.0 kg/hr (2 lb/hr). Other common buccinid snails were *Pyrulofusus harpa* and *Colus halli*.

The Oregon triton, *Fusitriton oregonensis* (family Cymatiidae), was another widespread and important gastropod (Fig. 12). It was most abundant at Station 74-C where the density was 0.4 g/m² or 4.5 kg (10 lbs) taken in a 35 minute (non-standard) tow. The average CPUE for this snail was 1.0 kg/hr (2 lbs/hr).

Two areas of biological interest in terms of species composition and diversity encompassed Stations 74-C and D, and Station 94-A and B (Fig. 1).

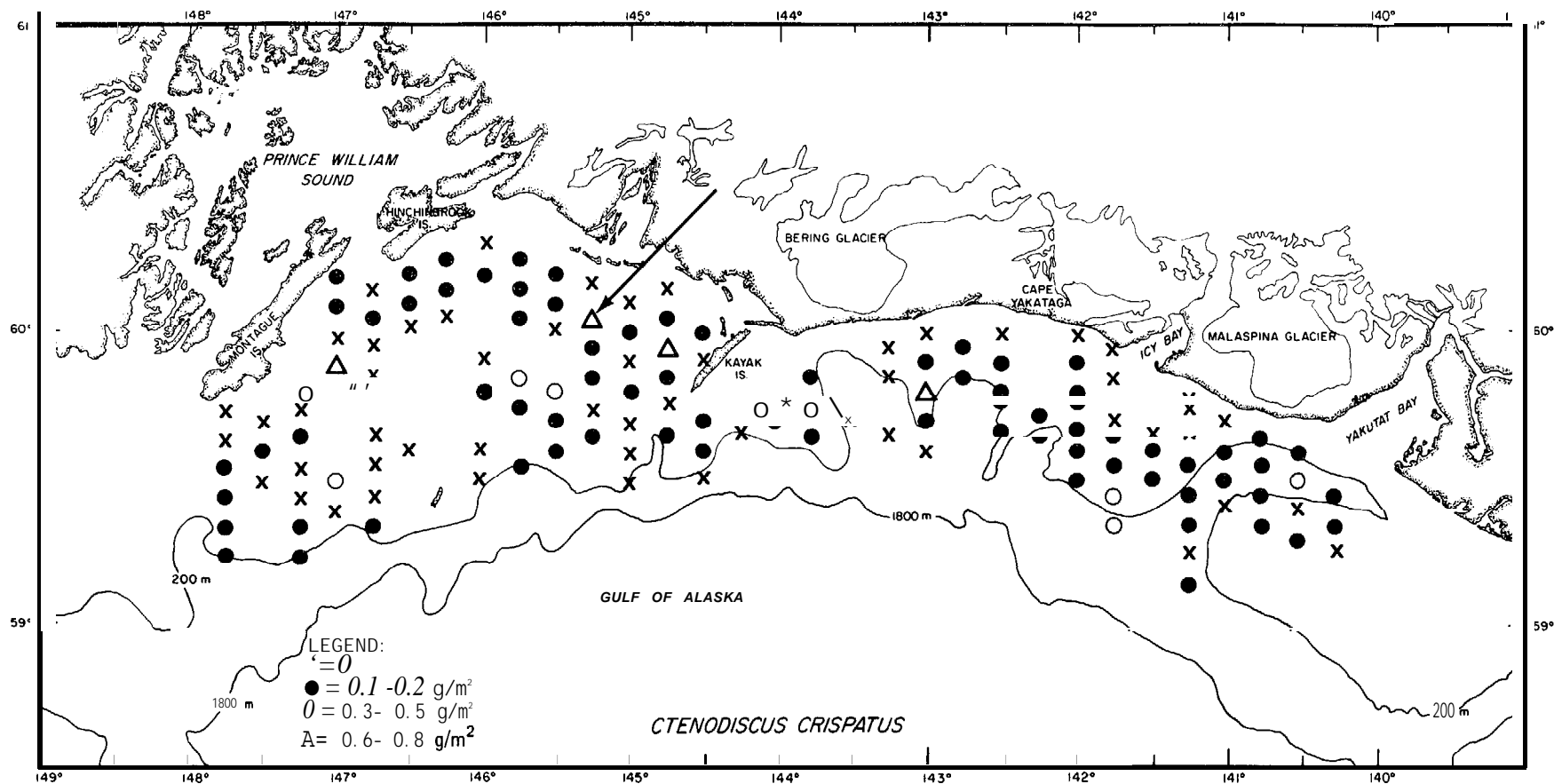


Figure 6. Distribution and abundance of the sea star, *Ctenodiscus crispatus*, from the northeastern Gulf of Alaska (NEGOA) trawl survey, summer 1975. Arrow indicates highest density of *C. crispatus*.

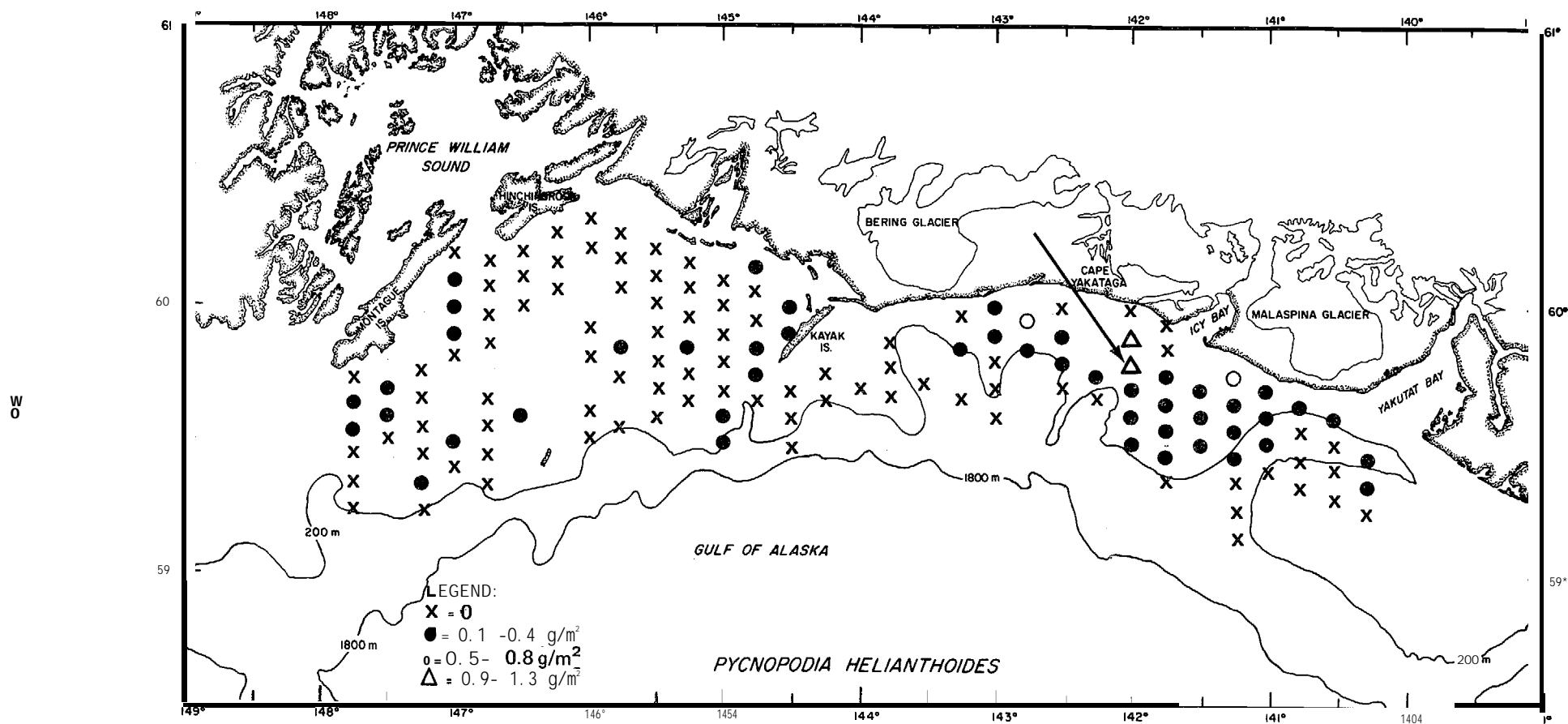


Figure 7. Distribution and abundance of the sea star, *Pycnopodia helianthoides*, from the north-eastern Gulf of Alaska (NEGOA) trawl survey, summer 1975. Arrow indicates highest density of *P. helianthoides*.

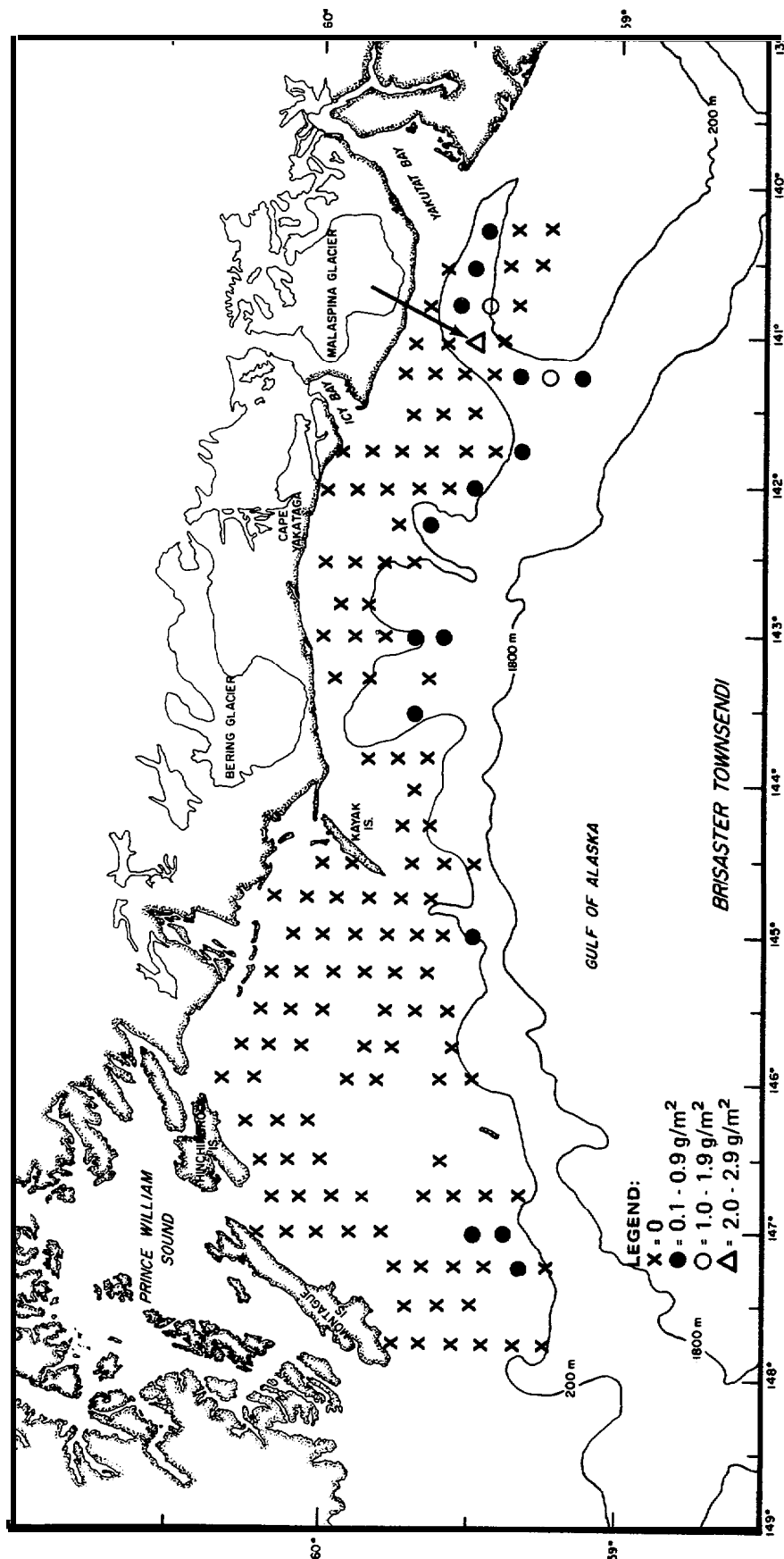


Figure 8. Distribution and abundance of the heart urchin, *Brisaster townsendi*, from the north-eastern Gulf of Alaska (NEGOA) trawl survey, summer 1975. Arrow indicates highest density of *B. townsendi*.

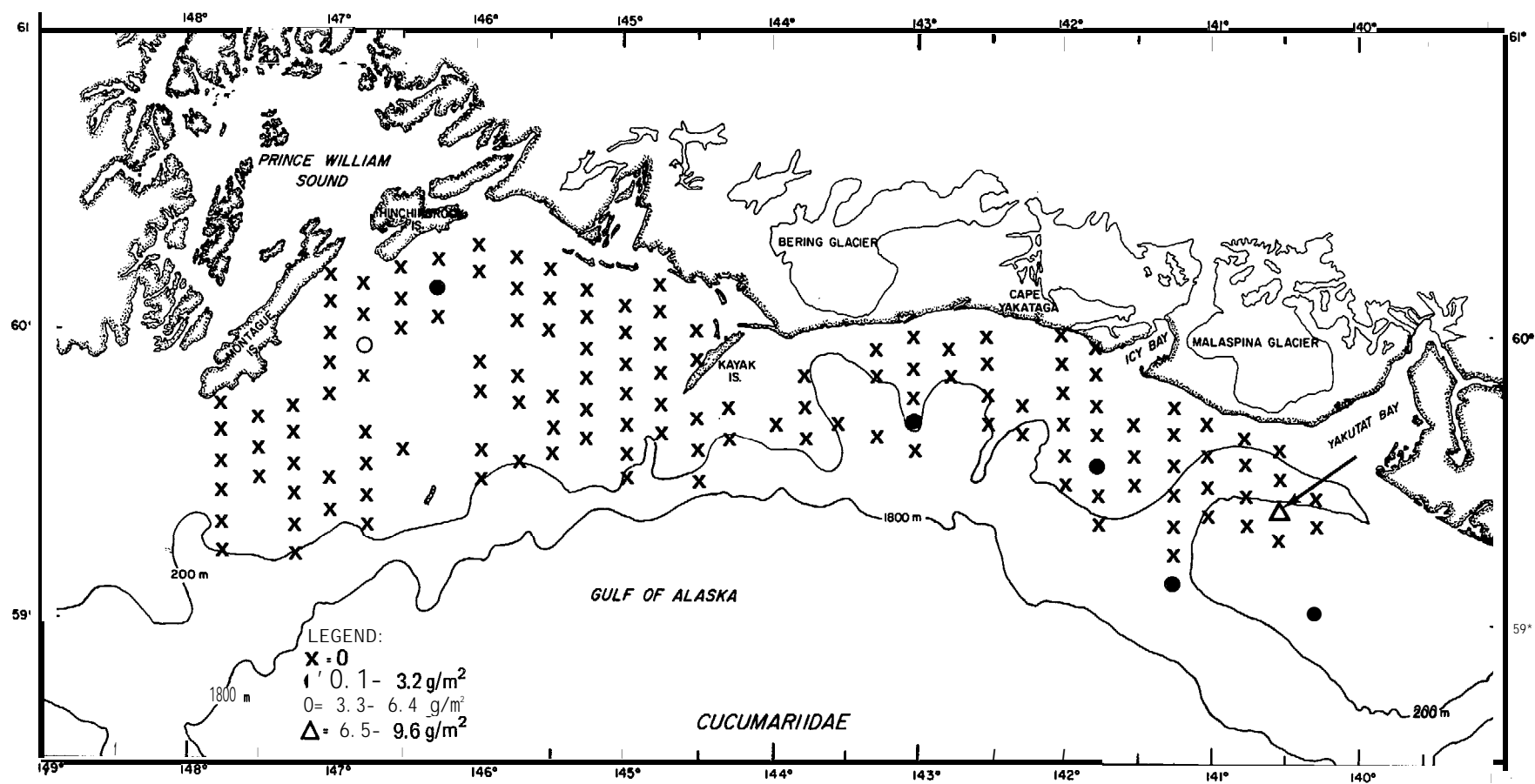


Figure 9. Distribution and abundance of the sea cucumber, family *Cucumariidae*, from the northeastern Gulf of Alaska (NEGOA) trawl survey, summer 1975. Arrow indicates highest density of *Cucumariidae*.

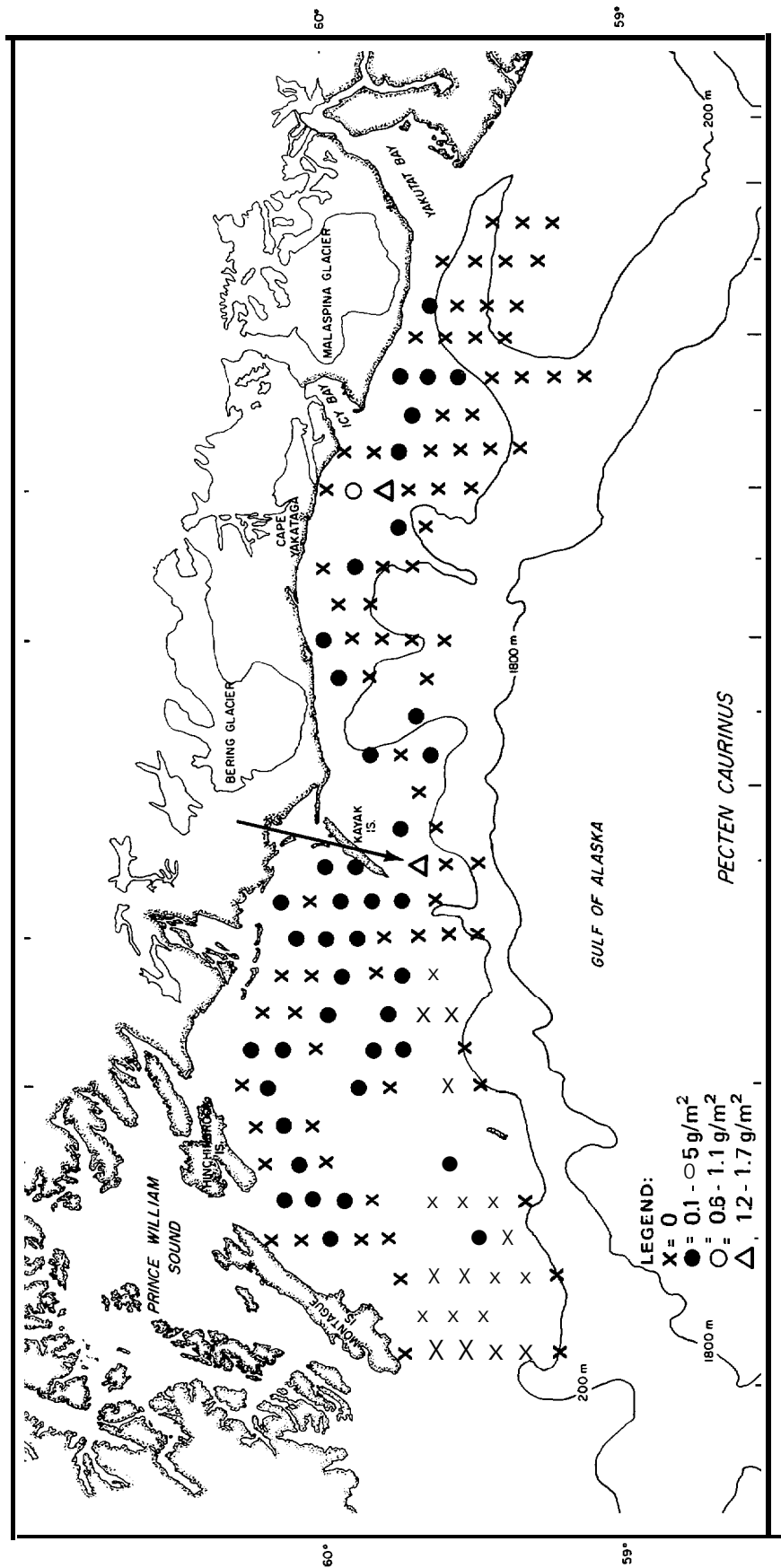


Figure 10. Distribution and abundance of the scallop, *Pecten caurinus*, from the northeastern Gulf of Alaska (NEGOA) trawl survey, summer 1975. Arrow indicates highest density of *P. caurinus*.

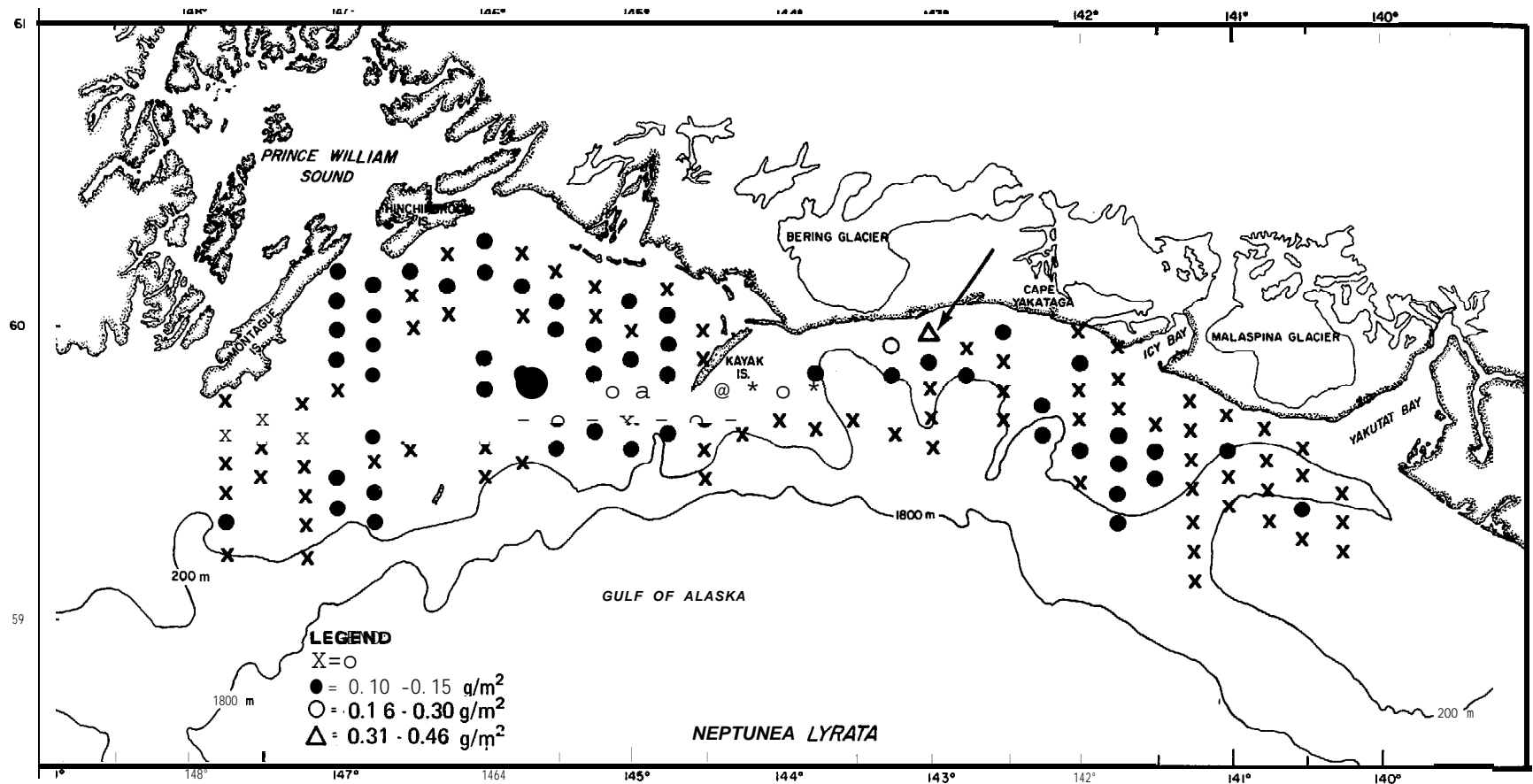


Figure 11. Distribution and abundance of the snail, *Neptunea lyrata*, from the northeastern Gulf of Alaska (NEGOA) trawl survey, summer 1975. Arrow indicates highest density of *N. lyrata*.

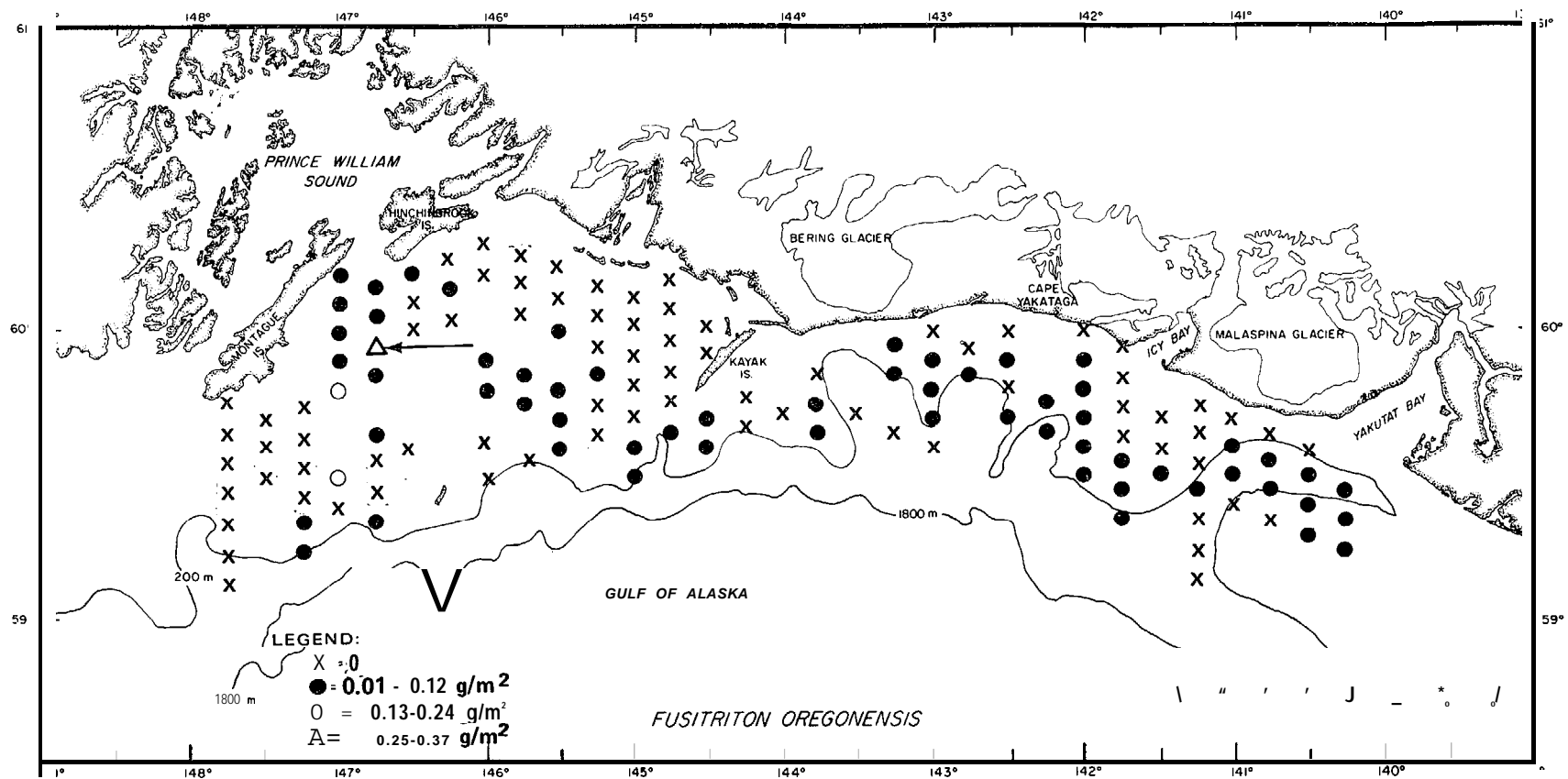


Figure 12. Distribution and abundance of the Oregon triton, *Fusitriton oregonensis*, from the north-eastern Gulf of Alaska (NEGOA) trawl survey, summer 1975. Arrow indicates highest density of *F. oregonensis*.

Stations 74-C and D contained seven species of fishes (*Hippoglossus stenolepis*, *Bathymaster signatus*, *Lepidopsetta bilineata*, *Gadus macrocephalus*, *Hemilepidotus jordani*, *Atheresthes stomias*, and *Glyptocephalus zachirus*), and had the highest diversity of invertebrates of all of the stations sampled. Crustaceans (14 species), echinoderms (13 species) and molluscs (13 species) made up 85% of the 47 species found there. The biomass of the ascidian, *Halocynthia helgendorfi igaboja*, at Station 74-c was 4.5 g/m² or 419.8 kg (925 lbs) taken per hour. The Pacific halibut, *Hippoglossus stenolepis*, dominated the fish catch at Station 74-C with 1299 kg (3084 lbs) taken per hour; each fish averaged 18.5 kg (41 lbs). Stations 94-A and B, off Icy Bay, were characterized by an abundance of three species of fishes (*Platichthys stellatus*, *Theragra chalcogramma*, and *Isopsetta isolepis*), and the near-absence of epifaunal invertebrates. Although the number of species of fishes was low, biomass was high. At Station 94-B, 4309 kg (9499 lbs) of fishes were taken in the one-hour tow.

Feeding Observations

Limited observations on the food habits of three species of sea stars and two species of flatfishes were made in the study area (Table IV).

The forcipulate sea star *Pycnopodia helianthoides*, a predatory echinoderm, was the most commonly encountered member of the family Asteridae. Eighty-six specimens were examined for feeding habits, 69 (80.2%) of which had been feeding. By frequency of occurrence, the brittle star, *Ophiura sarsi*, was the dominant prey species found in 39.1% of the *Pycnopodia* stomachs examined (Table IV). *Ctenodiscus crispatus* occurred in 18.8% of the stomachs examined, and was second in importance as a prey species. Seventy-eight percent (78%) of the stations at which *Pycnopodia* was found also contained *C. crispatus* and/or *O. sarsi*. Other prey consumed by *Pycnopodia* in order of diminishing frequency of occurrence, were the gastropod *Colus halli*, *Mitrella gouldi*, *Solariella obscura*, *Oenopota* sp. and *Natica clausa*, and the pelecypods *Serripes groenlandicus* and *Clinocardium ciliatum*.

The sea star, *Ctenodiscus crispatus*, a non-selective deposit feeder, was typically found with its stomach full of sediment.

Three specimens of *Luidia foliolata*, a moderately sized (to 12 inches in diameter) sea star were examined. The brittle star, *Ophiura sarsi*, and

TABLE IV

STOMACH CONTENTS OF SELECTED EPIFAUNAL INVERTEBRATES
AND FISHES FROM THE NORTHEAST GULF OF ALASKA, 1975

<u>Predator</u>	Percent Frequency of Occurrence	
	% of feeding fishes	% of total fishes
<i>Pycnopodia helianthoides</i> (Twenty-rayed star)		
Stomachs examined: 86		
Stomachs with food: 69		80.2%
Stomach contents: <i>Ophiura sarsi</i> (27)	39.1%	31.4%
<i>Ctenodiscus crispatus</i> (13)	18.8%	15.1%
<i>Natica clausa</i> (5)	7.2%	5.8%
<i>Colus halli</i> (3)	4.3%	3.5%
Cardiidae (3)	4.3%	3.5%
<i>Mitrella gouldi</i> (3)	4.3%	3.5%
Sediment (3)	4.3%	3.5%
<i>Buccinum plectrum</i> (1)	1.4%	1.2%
<i>Solarisella obscura</i> (1)	1.4%	1.2%
<i>Oenopota</i> sp. (1)	1.4%	1.2%
<i>Serripes groenlandicus</i> (1)	1.4%	1.2%
<i>Clinocardium ciliatum</i> (1)	1.4%	1.2%
Lyonsiidae (1)	1.4%	1.2%
<i>Mediaster aequalis</i> (1)	1.4%	1.2%
<i>Gorgonocephalus caryi</i> (1)	1.4%	1.2%
Unidentified gastropoda (1)	1.4%	1.2%
Unidentified pelecypoda (1)	1.4%	1.2%
Unidentified ophiuroidea (1)	1.4%	1.2%
<i>Luidia foliolata</i> (sea star)		
Stomachs examined: 3		
Only stomachs with food recorded		
Stomach contents: <i>Ophiura sarsi</i> (2)	66.6%	66.6%
Unidentified polychaeta (1)	33.3%	33.3%
<i>Crossaster papposus</i> (rose star)		
Stomachs examined: 1		
Only stomach with food recorded		
Stomach contents: <i>Ophiura sarsi</i>	100%	100%
<i>Platichthys stellatus</i>		
Stomachs examined: 30		
Stomachs with food: 30		100%
Stomach contents: <i>Yoldia seminuda</i> (30)	100%	100%
<i>Siliqua sloati</i> (30)	100%	100%
<i>Macoma dextroterata</i> (30)	100%	100%
<i>Hippoglossoides elassodon</i>		
Stomachs examined: 2		
Stomachs with food: 2		100%
Stomach contents: <i>Ophiura sarsi</i>	100%	100%

an unidentified polychaetous annelid were found in the stomachs of *Luidia*. *Ophiura sarsi* was also found in the stomach of the rose star, *Crossaster papposus*.

Starry flounders (*Platichthys stellatus*) dominated the catch off Icy Bay (Stations 94-A and B) (Fig. 1). Thirty of these starry flounders were examined for feeding habits. All were feeding heavily on three species of clams: *Yoldia seminuda*, *Siliqua alta*, and *Macoma dextosttera*. All stomachs were full.

Another common flatfish in NEGOA, the flathead sole (*Hippoglossoides elassodon*), was feeding on *Ophiura sarsi*.

Pollutants Taken by Trawl

Pollutants were recorded on the first two legs of the M/V *North Pacific* cruise which covered an area from Montague Island to Yakutat Bay. Thirty-three (33) stations out of 58 (57%) contained debris which consisted primarily of plastic materials such as brown and green trash bags, pieces of clear plastic (bait wrappers), and plastic binding straps. Numerous plastics of Japanese or Korean origin were found. A variety of other pollutants consisted of tarred paper, bottles, a steel cable, rubber gloves, a rubber tire, and two derelict snow crab pots. This high frequency of occurrence of pollutants within the surveyed area may give some indication of the amount of pollution throughout the north Pacific (Jewett, 1976).

VII. DISCUSSION

This investigation represents the first intensive qualitative and quantitative study of the epifaunal invertebrates of the northeast Gulf of Alaska (NEGOA). Hitz and Rathjen (1965) surveyed bottom fishes and invertebrates of the continental shelf in the NEGOA area; however, invertebrates were of secondary interest. Only major invertebrate species and/or groups were recorded. Additional data on commercially important shellfish species can be found in Ronholt *et al.* (1976).

The mean estimate of biomass, 2.6 g/m^2 , for the northeast Gulf of Alaska is similar to estimates of 3.3 g/m^2 for the inner portions of the continental shelf (<80 m) of the southeastern Bering Sea and 4.9 g/m^2 for the outer portion

of the continental shelf (mainly 80-400 m) of the southeastern Bering Sea (Feder *et al.*, 1978). Benthic trawl studies of the Norton Sound area and the Chukchi Sea-Kotzebue Sound area yielded biomass estimates of 3.7 g/m² and 3.3 g/m², respectively (Feder and Jewett, 1977b). Benthic investigations by Feder and Matheke (in prep.) provide biomass estimates based on grab samples for infauna and small epifauna from NEGOA. The lowest value, 7 g/m², and the highest value, 638 g/m², differ from our estimates based on epifauna only from NEGOA. The reason for difference in estimates is the type of gear used. Use of a commercial bottom trawl results in the loss of many small epibenthic species, and does not usually collect infauna, both of which are important components of benthic biomass. Therefore, a more accurate estimate of benthic standing stock will always be gained by combining both grab and trawl values.

The Outer Continental Shelf Environmental Assessment Program (OCSEAP) trawl surveys in the southeastern Bering Sea and Norton Sound-southeastern Chukchi Sea-Kotzebue Sound areas provided extensive information on epifauna that can be compared with data from NEGOA (Jewett and Feder, 1976; Ronholt *et al.*, 1976; Feder and Jewett, 1977b). The southeastern Bering Sea exhibited greater epifaunal diversity (233 species) than NEGOA (168 species) and Norton Sound-Chukchi Sea-Kotzebue Sound (187 species). NEGOA epifaunal invertebrate biomass was dominated by Arthropoda (71.4%), Echinodermata (19.0%), and Mollusca (4.6%). The biomass in the southeastern Bering Sea stations that were less than 80 m in depth was likewise dominated by Arthropoda (58.0%), Echinodermata (22.0%), and Mollusca (6.5%) (Feder *et al.*, 1978). At southeastern Bering Sea stations between 80 and 400 m, the biomass was also dominated by Arthropoda (66.9%), Echinodermata (11.1%), and Mollusca (4.6%) (Feder *et al.*, 1978). In contrast, the Norton Sound region was dominated by Echinodermata (80.3%), Arthropoda (9.6%), and Mollusca (4.4%) and the Chukchi Sea-Kotzebue Sound region was dominated by Echinodermata (59.9%), Mollusca (12.8%), and Arthropods (12.5%) (Feder and Jewett, 1977b). In general, arthropod biomass decreased toward higher latitudes and the echinoderm biomass increased.

The highest biomass values for the snow crab, *Chionoecetes bairdi*, the pink shrimp, *Pandalus borealis*, the brittle star, *Ophiura sarsi*, and the mud

star, *Ctenodiscus crispatus* were recorded southeast of Kayak Island, in the vicinity of the Copper River Delta (Fig. 1). Large concentrations of fishes were also present in this area (see Ronholt *et al.*, 1976, for distribution and density data for fishes there). Little is known about the productivity of this area, but primary and secondary production may be higher there as a result of nutrients supplied by the Copper River. Also, enhanced productivity may be related to the presence of gyres that extend vertically from the ocean surface to the bottom (Gait, 1976).

The two dominant arthropods, the snow crab (*Chionoecetes bairdi*) and the pink shrimp (*Pandalus borealis*) are widespread and commercially important in the northeast Gulf of Alaska. Snow crabs are major food of the Pacific cod (*Gadus macrocephalus*) (Feder, 1977a; Jewett, in press) and sculpins (*Myoxocephalus* spp.) (Jewett and Powell, unpubl.)². Pink shrimps are also a major food of Pacific cod (Feder, 1977a; Jewett, in press) as well as the turbot (*Atheresthes stomias*) and rex sole (*Glyptocephalus zachirus*) (Smith *et al.*, 1978).

Although determination of the food of snow crabs was not a part of the NEGOA study, inferences from other investigations suggest that food groups used by snow crabs (*Chionoecetes* spp.) are somewhat similar throughout their range. *Chionoecetes opilio* examined in the Bering Sea fed mainly on unidentified polychaetes and brittle stars, mainly *Ophiura* sp. (Feder *et al.*, 1978). The deposit-feeding clam, *Nucula tenuis*, dominated the diet of *Chionoecetes opilio* from Norton Sound and the Chukchi Sea (Feder and Jewett, 1978b). *Chionoecetes opilio* from the Gulf of St. Lawrence fed mainly on clams (*Yoldia* sp.) and polychaetes (Powles, 1968). *Chionoecetes opilio elongatus* from Japanese waters fed primarily on brittle stars (*Ophiura* sp.), young *C. opilio elongatus*, and protobranch clams (Yasuda, 1967). Most of the items consumed by *C. bairdi* from two bays of Kodiak Island were polychaetes, clams (*Nuculanidae*), shrimps, plants, and sediment (Feder and Jewett, 1977a). Paul *et al.* (in press), examined stomachs of *C. bairdi* from lower Cook Inlet and found the main items to be clams (*Macoma* spp.), hermit crabs (*Pagurus* spp.), barnacles (*Balanus* spp.) and sediment. *Chionoecetes bairdi*

²Detailed feeding information on Pacific cod and sculpins from the Kodiak shelf will be included in the Kodiak OCSEAP final report.

in Port Valdez (Prince William Sound) contained polychaetes, clams, *C. bairdi*, other crustaceans, and some detrital material (Feder, unpub. data). Further data on the distribution and abundance of potential prey species are necessary in order to better identify food species for better comparison of food from different areas.

The large sea star, *Pycnopodia helianthoides*, preyed almost entirely upon gastropod molluscs and echinoderms. *Pycnopodia* examined in Kodiak shallow waters preyed mainly on gastropod and pelecypods (Feder and Jewett, unpubl.). Intertidal and shallow sub-tidal *Pycnopodia helianthoides* from Prince William Sound were found to feed primarily on small bivalve molluscs (Paul and Feder, 1975). This sea star is also capable of excavating for large clams (Mauzey et al., 1968; Paul and Feder, 1975). King crabs have been observed (via SCUBA) near Kodiak to feed on *Pycnopodia* (S. Jewett and G. Powell, unpubl. observ.).

The mud star, *Ctenodiscus crispatus*, and the heart urchin, *Brisaster townsendi*, were encountered in large numbers within the study area. Both of these echinoderms use carbon associated with bottom sediments as their major source of nutrition (Feder, unpubl.). As deposit feeders, *Ctenodiscus* and *Brisaster* are continuously reworking and ingesting sediments, and probably have an important role in recycling nutrients. A large proportion of the NEGOA infaunal species is comprised of deposit feeders (Matheke et al., in press).

Although the feeding habits of the common brittle star, *Ophiura sarsi*, were not extensively examined in this study, it probably uses a combination of browsing, detritus feeding, and prey-capture techniques (Gentleman, 1964; Kyte, 1969). A few *O. sarsi* examined in NEGOA, the southeastern Bering Sea and Port Valdez (Prince William Sound) mainly contained detrital material and sediment but also fragments of a variety of small benthic invertebrates (Feder, unpubl.). In turn, this brittle star is important food for the clover sole (*Microstomus pacificus*) and the flathead sole (*Hippoglossoides elassodon*) (Smith et al., 1978).

All of the specimens of the starry flounder (*Platichthys stellatus*) examined in this study had been feeding intensively and exclusively on three species of clams (*Yoldia seminuda*, *Siliqua sloati*, and *Macoma dextroterata*). Clams, especially thin shelled species, have been found to be important

components in the diet of starry flounders by other investigators (Villadolid, 1927; Orcutt, 1950; Moiseev, 1953; Miller, M.S., 1965). Starry flounders from the northern Bering Sea and the southeastern Chukchi Sea were found to feed heavily on *Yoldia hyperborea* and the brittle star *Diamphiodia craterodonta* (Feder and Jewett, 1977b). A definite seasonality in feeding intensity has been found to exist for this flounder: during the months of January through late May a cessation of feeding occurs; feeding resumes in late May or early June (Feder and Jewett, unpub. OCSEAP data; Miller, M.S., 1965). The degree of fullness of the starry flounders examined in this study may be evidence of a recently terminated fasting period. All of the specimens were taken at Stations 94-A and B on 3 June 1975. Clam populations in the Icy Bay area obviously play a vital role in the trophic dynamics of *P. stellatus*.

VIII. CONCLUSIONS

The major limitations of the survey were those imposed by the selectivity of the otter trawl used and the seasonal movements of certain species taken. In addition, rocky-bottom areas were not sampled since otter trawls of the type used can only be fished on a relatively smooth bottom. However, the study reported here was effective for determining the epibenthic invertebrates present on sediment bottom and for achieving maximum spatial coverage of the area. This report, in conjunction with the NEGOA infaunal investigation (Feder and Matheke, in prep.), will enhance our understanding of the shelf ecosystem.

Availability of many readily identifiable, biologically well-understood organisms is a preliminary to the development of monitoring programs. Sizeable biomasses of taxonomically well-known molluscs, crustaceans, and echinoderms were typical of most of our stations, and many species of these phyla were sufficiently abundant to represent organisms potentially useful as monitoring tools. The present investigation should clarify some aspects of the biology of many of these organisms, and should increase the reliability of future monitoring programs for the Gulf of Alaska.

IX. NEEDS FOR FURTHER STUDY

The extensive trawl program permitted complete coverage of the benthos for epifaunal invertebrates. However, considerable effort is still needed to understand the NEGOA benthic system. It is especially important that chemical, physical and geological data be collected in conjunction with all future biological investigations.

Selected epifaunal species should be chosen for intensive study as soon as possible so that basic information will be available to a monitoring program. Specific biological parameters that should be examined are reproduction, recruitment, growth, age, feeding biology, and trophic interactions with other invertebrates and vertebrates.

Grouping techniques, such as cluster or recurrent group analysis, provide methods for delineating station and species groups. The outcome of such analyses can be used to delimit areas of monitoring programs. Future application of grouping techniques to epifaunal species should be strongly encouraged.

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APPENDIX

GULF OF ALASKA - SELECTED **BENTHIC** TRAWL STATION DATA

3 MAY 1975 THROUGH 7 AUGUST 1975

CRUISE NUMBER **N0817**

NO 817

TABLE I

TOW NUMBER 14; STATION NUMBER 74-C; PERCENT SAMPLED = 50.

(All counts and weights are projected to 100% of the sample).

Date				Start				Finish				Time		Distance		Depth	
				Latitude		Longitude		Latitude		Longitude		Fished	Time	Fished		Fished	
Yr	Mo	Da		Hr	/Min	Deg	Min	Deg	Min	Deg	Min	Deg	Min	Min	Zone	(lull)	(m)
7	5	5	8	14	00	58	57.0	146	45.0	59	59.0	146	43.0	35	9	4.44	63.7-67.3

TAXON	COUNT			WET WEIGHT (gin)		
	No.	%	Per km	Total	%	Per km
<u>INVERTEBRATES</u>						
Porifera	6.0	0.1	1.4	2700.0	0.6	608.1
<i>Ptilosarcus gurneyi</i>	46.0	0.7	10.4	2760.0	0.7	621.6
Actiniidae	12.0	0.2	2.7	2400.0	0.6	540.5
<i>Modiolus modiolus</i>	20.0	0.3	4.5	2200.0	0.5	495.5
<i>Chlamys hastata hericia</i>	400.0	6.3	90.1	3200.0	0.8	720.7
<i>Pecten caurinus</i>	12.0	0.2	2.7	1320.0	0.3	297.3
<i>Astarte polaris</i>	8.0	0.1	1.8	80.0	0.0	18.0
<i>Clinocardium fucanum</i>	2.0	0.0	0.5	8.0	0.0	1.8
<i>Serripes groenlandicus</i>	4.0	0.1	0.9	800.0	0.2	180.2
<i>Lischkeia cidaris</i>	150.0	2.4	33.8	1800.0	0.4	405.4
<i>Fusitriton oregonensis</i>	260.0	4.1	58.6	19940.0	4.7	4491.0
<i>Buccinum plectrum</i>	40.0	0.6	9.0	800.0	0.2	180.2
<i>Neptunea lyrata</i>	30.0	0.5	6.8	5440.0	1.3	90.1
<i>Pyrulofusus harpa</i>	4.0	0.1	0.9	400.0	0.1	90.1
Tritoniidae	4.0	0.1	0.9	600.0	0.1	135.1
<i>Tochuina tetraquetra</i>	4.0	0.1	0.9	600.0	0.1	135.1
<i>Balanus</i> sp.	302.0	4.7	68.0	9060.0	2.1	2040.5

TABLE I

CONTINUED

TAXON	COUNT			WET WEIGHT (gin)		
	No.	%	Per km	Total	%	Per km
<i>Pandalus montagui tridens</i>	12.0	0.2	2.7	96.0	0.0	21.6
<i>Paracrangon echinata</i>	24.0	0.4	5.4	168.0	0.0	37.8
<i>Pagurus ochotensis</i>	150.0	2.4	33.8	13600.0	3.2	3063.1
<i>Pagurus aleuticus</i>	12.0	0.2	2.7	1320.0	0.3	297.3
<i>Pagurus kennerlyi</i>	40.0	0.6	9.0	4520.0	1.1	1018.0
<i>Elassochirus tenuimanus</i>	40.0	0.6	9.0	4520.0	1.1	1018.0
<i>Elassochirus cavimanus</i>	38.0	0.6	8.6	4520.0	1.1	1018.0
<i>Labidochirus splendescens</i>	24.0	0.4	5.4	1200.0	0.3	270.3
<i>Lopholithodes foraminatus</i>	2.0	0.0	0.5	840.0	0.2	189.2
<i>Rhinolithodes wosnessenskii</i>	16.0	0.3	3.6	2880.0	0.7	648.6
<i>Oregonia gracilis</i>	14.0	0.2	3.2	2520.0	0.6	567.6
<i>Hyas lyratus</i>	20.0	0.3	4.5	3620.0	0.9	815.3
<i>Cancer oregonensis</i>	24.0	0.4	5.4	140.0	0.0	31.5
<i>Terebratulina unguicula</i>	864.0	13.5	194.6	6040.0	1.4	1360.4
<i>Laqueus californianus</i>	864.0	13.5	194.6	6040.0	1.4	1360.4
<i>Terebratalia transversa</i>	864.0	13.5	194.6	6040.0	1.4	1360.4
<i>Ceramaster paragonicus</i>	14.0	0.2	3.2	980.0	0.2	220.7
<i>Henricia</i> sp.	50.0	0.8	11.3	3500.0	0.8	788.3
<i>Henricia aspera</i>	12.0	0.2	2.7	1200.0	0.3	270.3
<i>Poraniopsis inflata</i>	6.0	0.1	1.4	1320.0	0.3	297.3
<i>Pteraster tessellatus</i>	90.0	1.4	20.3	19800.0	4.7	4459.5
<i>Crossaster papposus</i>	44.0	0.7	9.9	3520.0	0.8	792.8
<i>Solaster dawsoni</i>	24.0	0.4	5.4	4800.0	1.1	1081.1
<i>Lethasterias nanimensis</i>	20.0	0.3	4.5	4000.0	0.9	900.9
<i>Stylasterias forreri</i>	16.0	0.3	3.6	640.0	0.2	144.1
<i>Strongylocentrotus droebachiensis</i>	496.0	7.8	111.7	14880.0	3.5	3351.4
<i>Gorgonocephalus caryi</i>	12.0	0.2	2.7	480.0	0.1	108.1
<i>Ophiura sarsi</i>	24.0	0.4	5.4	140.0	0.0	31.5
Cucumariidae	36.0	0.6	8.1	12240.0	2.9	2756.8
<i>Halocynthia hilgendorfi igaboja</i>	1224.0	19.2	275.7	244940.0	57.7	55166.7

TABLE I

CONTINUED

TAXON	COUNT			WET WEIGHT (gin)		
	No.	%	Per km	Total	%	Per km
<u>VERTEBRATES</u>						
<i>Bathymaster signatus</i>				64860.0	7.1	14608.1
<i>Hippoglossus stenolepis</i>				816480.0	88.9	183891.9
<i>Lepidopsetta bilineata</i>				37180.0	4.0	8373.9

COMMENTS

Weights of hermit crabs include their shells. This tow contains many small round rocks (4 cm in diameter), weights of some asidians include several small rocks which the asidians are attached.

TABLE II

TOW NUMBER 146; STATION NUMBER 74-D; PERCENT SAMPLED = 100.

Date				Start				Finish				Time		Distance		Depth	
				Latitude		Longitude		Latitude		Longitude		Fished	Time	Fished	Fished		
Yr	Mo	Da		Hr	/Min	Deg	Min	Deg	Min	Deg	Min	Deg	Min	Min	Zone	(km)	(m)
7	5	8	6	13	05	59	53.0	146	51.0	59	51.0	146	53.0	30	9	3.52	67.3-71.0

TAXON	COUNT			WET WEIGHT (gin)		
	No.	%	Per km	Total	%	Per km
<u>INVERTEBRATES</u>						
<i>Ptilosarcus gurneyi</i>	50.0	1.0	14.2	3000.0	2.0	852.3
<i>Artonoe vittata</i>	1.0	0.0	0.3	1.0	0.0	0.3
<i>Nereis pelagica</i>	2.0	0.0	0.6	20.0	0.0	5.7
<i>Eunice valens</i>	2.0	0.0	0.6	2.0	0.0	0.6
<i>Modiolus modiolus</i>	6.0	0.1	1.7	660.0	0.4	187.5
<i>Hiatella arctica</i>	1.0	0.0	0.3	3.0	0.0	0.9
<i>Lischkeia cidaris</i>	1.0	0.0	0.3	12.0	0.0	3.4
<i>Fusitriton oregonensis</i>	20.0	0.4	5.7	2000.0	1.4	568.2
<i>Trophonopsis stuarti</i>	2.0	0.0	0.6	20.0	0.0	5.7
<i>Neptunea lyrata</i>	20.0	0.4	5.7	3600.0	2.4	1022.7
Dorididae	40.0	0.8	11.4	6000.0	4.1	1704.5
<i>Tritonia exsulans</i>	2.0	0.0	0.6	300.0	0.2	85.2
<i>Balanus hesperius</i>	11.0	0.2	3.1	330.0	0.2	93.8
<i>Pandalus hypsinotus</i>	200.0	4.0	56.8	1600.0	1.1	454.5
<i>Paracrangon echinata</i>	1.0	0.0	0.3	7.0	0.0	2.0
<i>Pagurus kennerlyi</i>	20.0	0.4	5.7	2200.0	1.5	625.0
<i>Elassochirus cavimanus</i>	4.0	0.1	1.1	480.0	0.3	136.4
<i>Lopholithodes foraminatus</i>	3.0	0.1	0.9	1260.0	0.9	358.0
<i>Hyas lyratus</i>	9.0	0.2	2.6	1620.0	1.1	460.2
<i>Terebratulina unguicula</i>	1000.0	20.1	284.1	7000.0	4.8	1988.6
<i>Laqueus californianus</i>	1000.0	20.1	284.1	7000.0	4.8	1988.6

TABLE II

CONTINUED

TAXON	COUNT			WET WEIGHT (gin)		
	No.	%	Per km	Total	%	Per km
<i>Terebratalia transversal</i>	1000.0	20.1	284.1	7000.0	4.8	1988.6
<i>Luidiaster dawsomi</i>	2.0	0.0	0.6	440.0	0.3	125.0
<i>Ceramaster patagonicus</i>	2.0	0.0	0.6	140.0	0.1	39.8
<i>Henricia aspera</i>	8.0	0.2	2.3	800.0	0.5	227.3
<i>Poraniopsis inflata</i>	1.0	0.0	0.3	220.0	0.1	62.5
<i>Pteraster tessellatus</i>	30.0	0.6	8.5	6600.0	4.5	1875.0
<i>Crossaster papposus</i>	40.0	0.8	11.4	3200.0	2.2	909.1
<i>Solaster dawsoni</i>	3.0	0.1	0.9	600.0	0.4	170.5
<i>Leptasterias</i> sp.	3.0	0.1	0.9	27.0	0.0	7.7
<i>Strongylocentrotus droebachiensis</i>	1288.0	25.8	365.9	46720.0	31.7	13272.7
<i>Gorgonocephalus caryi</i>	9.0	0.2	2.6	3420.0	2.3	971.6
<i>Halocynthia hilgendorfi igaboja</i>	200.0	4.0	56.8	40000.0	27.2	11363.6
<i>Chelyosoma columbianum</i>	4.0	0.1	1.1	800.0	0.5	227.3
<i>Halocynthia aurantium</i>	1.0	0.0	0.3	200.0	0.1	56.8

VERTEBRATES

<i>Gadus macrocephalus</i>	-	3180.0	3.7	903.4
<i>Hemilepidotus jordani</i>	-	3630.0	4.2	1031.3
<i>Bathymaster signatus</i>	-	33110.0	38.3	9406.3
<i>Atheresthes stomias</i>	-	17240.0	20.0	4897.7
<i>Glyptocephalus zachirus</i>	-	2940.0	3.4	835.2
<i>Hippoglossus stenolepis</i>	-	17240.0	20.0	2897.7
<i>Lepidopsetta bilineata</i>	-	9070.0	10.5	2576.5

COMMENTS

Halocynthia aurantium attached to pebbles, *Halocynthia hilgendorfi igaboja* with 3 species of Brachiopoda attached. Hermit crabs weighed with shell, Gulf of Alaska - Benthic trawl data - 3 May 1975 thru 7 August 1975. Hung up, web ripped. Pollutants were not recorded.

TABLE III

TOW NUMBER 35; STATION NUMBER 80-B; PERCENT SAMPLED = 65.

(All counts and weights are projected to 100% of the sample).

Date Yr Mo Da	Time Hr/Min	Start		Finish		Time Fished Min	Time Zone	Distance Fished (lull)	Depth Fished (m)
		Latitude Deg Min	Longitude Deg Min	Latitude Deg Min	Longitude Deg Min				
75 5 24	1055	60 6.0	145 20.0	60 5.0	145 13.0	60	9	5.55	91.0-112.8

TAXON	COUNT			WET WEIGHT (gin)		
	No.	%	Per km	Total	%	Per km

INVERTEBRATES

<i>Ptilosarcus gurneyi</i>	173.8	2.7	31.3	10446.2	3.0	1882.2
<i>Buccinum plectrum</i>	4.6	0.1	0.8	92.3	0.0	16.6
octopus Sp.	6.2	0.1	1.1	200.0	0.1	36.0
<i>Pagurus ochotensis</i>	6.2	0.1	1.1	553.8	0.2	99.8
<i>Chionoecetes bairdi</i>	615.4	9.6	110.8	279138.5	80.6	50295.2
<i>Ctenodiscus crispatus</i>	5581.5	87.4	1005.7	55815.4	16.1	10056.8

VERTEBRATES

<i>Gadus macrocephalus</i>				55123.1	16.1	9932.1
<i>Theragra chalcogramma</i>				170261.5	49.7	30677.8
<i>Atheresthes stomias</i>				68384.6	20.0	12321.6
<i>Hippoglossoides elassodon</i>				48846.2	14.3	8801.1

COMMENTS

Weight of hermit crab includes their shells. Plastic found.

TABLE IV

TOW NUMBER 110; STATION NUMBER 81-D; PERCENT SAMPLED = 40.

(All counts and weights are projected to 100% of the sample).

Date Yr Mo Da	Time Hr /Min	Start		Finish		Time Fished Min	Time Zone	Distance Fished (km)	Depth Fished (m)
		Latitude Deg Min	Longitude Deg Min	Latitude Deg Min	Longitude Deg Min				
75 7 15	1305	59 49.0	145 0	59 46.0	145 2.0	60	9	5.37	182.0-193.0

TAXON	COUNT			WET WEIGHT (gin)		
	No.	%	Per km	Total	%	Per km
<u>INVERTEBRATES</u>						
<i>Actiniidae</i>	2.5	0.0	0.5	500.0	0.0	93.1
<i>Neptunea lyrata</i>	-2.5	0.0	0.5	450.0	0.0	83.8
<i>Neptunea pribiloffensis</i>	117.5	0.1	21.9	21150.0	1.5	3938.5
<i>Tritonia exsulans</i>	50.0	0.0	9.3	7500.0	0.5	1396.6
Gonatidae	2.5	0.0	0.5	50.0	0.0	9.3
<i>Octopus sp.</i>	2.5	0.0	0.5	225.0	0.0	41.9
<i>Pandalus borealis</i>	125.0	0.1	23.3	1000.0	0.1	186.2
<i>Pandalopsis dispar</i>	50.0	0.0	9.3	500.0	0.0	93.1
<i>Pagurus aleuticus</i>	25.0	0.0	4.7	275.0	0.0	51.2
<i>Chionoecetes bairdi</i>	1300.0	1.0	242.1	58500.0	42.3	108939.5
<i>Pseudarchaster parelii</i>	2.5	0.0	0.5	225.0	0.0	41.9
<i>Ctenodiscus crispatus</i>	1562.5	1.2	291.0	15625.0	1.1	2909.7
<i>Ophiura sarsi</i>	125000.0	97.5	23277.5	750000.0	54.2	139664.8
<u>VERTEBRATES</u>						
<i>Raja rhina</i>				32875.0	8.4	6122.0
<i>Gadus macrocephalus</i>				79375.0	20.3	14781.2
<i>Sebastolobus alascanus</i>				17575.0	4.5	3272.8

TABLE IV

CONTINUED

TAXON	COUNT			WET WEIGHT (gin)		
	No.	%	Per km	Total	z	Per km
<i>Anoplopoma fimbria</i>				19275.0	4.9	3589.4
<i>Atheresthes stomias</i>				46475.0	11.9	8654.6
<i>Glyptocephalus zachirus</i>				92975.0	23.8	17313.8
<i>Hippoglossoides elassodon</i>				2825.0	0.7	526.1
<i>Microstomus pacificus</i>				99775.0	25.5	18580.1

COMMENTS

Hermit crabs weighed with shell. Pollutants were not recorded.

TABLE V

TOW NUMBER 106; STATION NUMBER 82-A; PERCENT SAMPLED = 50.

(All counts and weights are projected to 100% of the sample).

Date			Start				Finish				Time	Time	Distance	Depth		
Yr	Mo	Da	Latitude	Longitude		Latitude	Longitude		Fished	Fished	Fished					
			Deg	Min	Deg	Min	Deg	Min	Deg	Min	Min	Zone	(km)	(m)		
75	7	14		1300	60	7.0	144	46.0	60	6.0	144	41.0	55	9	3.70	49.1-51.0

TAXON	COUNT			WET WEIGHT (gin)		
	No.	%	Per km	Total	%	Per km
<u>INVERTEBRATES</u>						
<i>Ptilosarcus gurneyi</i>	324.0	10.7	87.6	19440.0	2.1	5254.1
<i>Actiniidae</i>	2.0	0.1	0.5	400.0	0.0	108.1
<i>Nuculana fossa</i>	8.0	0.3	2.2	8.0	0.0	2.2
<i>Pecten caurinus</i>	4.0	0.1	1.1	1400.0	0.1	378.4
<i>Tritonia exsulans</i>	2.0	0.1	0.5	300.0	0.0	81.1
<i>Pandalus borealis</i>	600.0	19.9	162.2	4800.0	0.5	1297.3
<i>Pandalus hypsinotus</i>	36.0	1.2	9.7	280.0	0.0	75.7
<i>Eualis barbata</i>	2.0	0.1	0.5	14.0	0.0	3.8
<i>Eualis suckleyi</i>	2.0	0.1	0.5	14.0	0.0	3.8
<i>Crangon communis</i>	4.0	0.1	1.1	28.0	0.0	7.6
<i>Pagurus ochotensis</i>	6.0	0.2	1.6	540.0	0.1	145.9
<i>Chionoecetes bairdi</i>	1984.0	65.8	536.3	892800.0	95.2	241297.3
<i>Cancer magister</i>	34.0	1.1	9.2	15300.0	1.6	4135.1
<i>Pycnopodia helianthoides</i>	6.0	0.2	1.6	2700.0	0.3	729.7
<u>VERTEBRATES</u>						
<i>Theragra chalcogramma</i>				32200.0	17.2	8702.7
<i>Anoplopoma fimbria</i>				4080.0	2.2	1102.7

TABLE V
CONTINUED

TAXON	COUNT			WET WEIGHT (gin)		
	No.	%	Per km	Total	%	Per km
<i>Agonus acipenserinus</i>				15860.0	8.5	4286.5
<i>Lumpenus sagitta</i>				6160.0	3.3	1664.9
<i>Atheresthes stomias</i>				70760.0	37.9	19124.3
<i>Hippoglossoides elassodon</i>				57700.0	30.9	15594.6

COMMENTS

Hermit crabs weighed with shell. *Pycnopodia helianthoides* feeding on *Mitrella gouldi*. Pollutants were not recorded.

TABLE VI

TOW NUMBER 104; STATION NUMBER 83-C; PERCENT SAMPLED = 10.

(All counts and weights are projected to 100% of the sample).

Date			Start				Finish				Time		Distance	Depth
Yr	Mo	Da	Time	Latitude	Longitude	Latitude	Longitude	Latitude	Longitude	Fished	Time		Fished	Fished
			Hr /Min	Deg Min	Deg Min	Deg Min	Deg Min	Deg Min	Deg Min	Min	Zone		(km)	(m)
75	7	14	0745	59 52.0	144 38.0	59 56.0	144 34.0			60	9		5.55	54.6-54.6

TAXON	COUNT			WET WEIGHT (gin)		
	No.	%	Per km	Total	%	Per km
<u>INVERTEBRATES</u>						
<i>Ptilosarcus gurneyi</i>	222.0	1.0	39.6	13200.0	3.0	2378.4
<i>Nuculana fossa</i>	30.0	0.1	5.4	30.0	0.0	5.4
<i>Peeten caurinus</i>	30.0	0.1	5.4	10500.0	2.4	1891.9
<i>Balanus herperius</i>	10.0	0.0	1.8	300.0	0.1	54.1
<i>Pandalus borealis</i>	20970.0	95.8	3778.4	167700.0	38.5	30216.2
<i>Pandalus hypsinotus</i>	30.0	0.1	5.4	240.0	0.1	43.2
<i>Eualis suckleyi</i>	30.0	0.1	5.4	210.0	0.0	37.8
<i>Lopholithodes foraminatus</i>	10.0	0.0	1.8	4200.0	1.0	756.8
<i>Chionoecetes bairdi</i>	500.0	2.3	90.1	225000.0	51.6	40540.5
<i>Cancer magister</i>	10.0	0.0	1.8	4500.0	1.0	810.8
<i>Pycnopodia helianthoides</i>	20.0	0.1	3.6	9000.0	2.1	1621.6
<i>Strongylocentrotus droebachiensis</i>	30.0	0.1	5.4	900.0	0.2	162.2
<i>Molpadia</i> sp.	10.0	0.0	1.8	200.0	0.0	36.0

VERTEBRATES

<i>Raja binoculata</i>	226800.0	52.1	40864.9
<i>Theragra chalcogramma</i>	54430.0	12.5	9807.2

TABLE VI

CONTINUED

TAXON	COUNT			WET WEIGHT (gin)		
	No.	%	Per km	Total	%	Per km
<i>Anoplopoma fimbria</i>				22600.0	5.2	4072.1
<i>Atheresthes stomias</i>				104320.0	24.0	18796.4
<i>Hippoglossus steno lepis</i>				27210.0	6.3	4902.7

TABLE VII

TOW NUMBER 142; STATION NUMBER 83-E; PERCENT SAMPLED = 100.

Date				Time	Start		Finish		Time Fished	Time Zone	Distance Fished (km)	Depth Fished (m)
					Latitude	Longitude	Latitude	Longitude				
Yr	Mo	Da		Hr /Min	Deg Min	Deg Min	Deg Min	Deg Min	Min			
7	5	8	4	0800	59 43.0	144 37.0	59 41.0	144 33.0	60	9	5.55	129.2-131.0

TAXON	COUNT			WET WEIGHT (gin)		
	No.	%	Per km	Total	%	Per km
<u>INVERTEBRATES</u>						
Porifera	0.0	0.0	0.0	7900.0	4.7	1423.4
<i>Nereis pelagica</i>	1.0	0.0	0.2	10.0	0.0	1.8
<i>Nereis vexillosa</i>	1.0	0.0	0.2	10.0	0.0	1.8
Hirudinae	1.0	0.0	0.2	2.0	0.0	0.4
<i>Mytilus edulis</i>	100.0	2.4	18.0	2000.0	1.2	360.4
<i>Pecten caurinus</i>	330.0	7.8	59.5	115500.0	68.9	20810.8
<i>Hiatella arctica</i>	1.0	0.0	0.2	3.0	0.0	0.5
<i>Fusitriton oregonensis</i>	6.0	0.1	1.1	600.0	0.4	108.1
<i>Buccinum plectrum</i>	1.0	0.0	0.2	20.0	0.0	3.6
<i>Neptunea lyrata</i>	4.0	0.1	0.7	720.0	0.4	129.7
<i>Pyrulofusus harpa</i>	1.0	0.0	0.2	100.0	0.1	18.0
octopus Sp.	1.0	0.0	0.2	90.0	0.1	16.2
<i>Lepas pectinata pacifica</i>	1.0	0.0	0.2	30.0	0.0	5.4
<i>Pandalus borealis</i>	1100.0	26.1	198.2	8800.0	5.2	1585.6
<i>Crangon communis</i>	3.0	0.1	0.5	21.0	0.0	3.8
<i>Argis dentata</i>	1.0	0.0	0.2	7.0	0.0	1.3
<i>Pagurus aleuticus</i>	29.0	0.7	5.2	3190.0	1.9	574.8
<i>Pagurus confragosus</i>	12.0	0.3	2.2	1320.0	0.8	237.8
<i>Elassochirus cavimanus</i>	1.0	0.0	0.2	120.0	0.1	21.6
<i>Hyas lyratus</i>	6.0	0.1	1.1	1080.0	0.6	194.6

TABLE VII

CONTINUED

TAXON	COUNT			WET WEIGHT (gin)		
	No.	%	Per km	Total	%	Per km
<i>Chionoecetes bairdi</i>	17.0	0.4	3.1	7650.0	4.6	1378.4
<i>Pseudarchaster parelii</i>	1.0	0.0	0.2	90.0	0.1	16.2
<i>Ctenodiscus crispatus</i>	600.0	14.2	108.1	6000.0	3.6	1081.1
<i>Henricia aspera</i>	1.0	0.0	0.2	100.0	0.1	18.0
<i>Gorgonocephalus caryi</i>	1.0	0.0	0.2	380.0	0.2	68.5
<i>Ophiura sarsi</i>	2000.0	27.4	360.4	12000.0	7.2	2162.2
<u>VERTEBRATES</u>						
<i>Raja kincaidii</i>	-			2270.0	1.2	409.0
<i>Raja rhina</i>				3860.0	2.1	695.5
<i>Thaleichthys pacificus</i>				1360.0	0.7	245.0
<i>Theragra chalcogramma</i>				47170.0	25.9	8499.1
<i>Ulua bolini</i>				4540.0	2.5	818.0
<i>Atheresthes stomias</i>				82560.0	45.3	14875.7
<i>Glyptocephalus zachirus</i>				19500.0	10.7	3513.5
<i>Hippoglossoides elassodon</i>				5900.0	3.2	1063.1
<i>Microstomus pacificus</i>				14970.0	8.2	2697.3

COMMENTS

C. bairdi sexed, 12 males, 2 nongravid females, 3 gravid females. *Mytilus edulis* attached to Kelp holfast.
 Hermit crabs weighed with shell. Pollutants were not recorded.

TABLE VIII

TOW NUMBER 42; STATION NUMBER 86-D; PERCENT SAMPLED = 100.

Date			Time	Start		Finish		Time		Distance	Depth
Yr	Mo	Da	Hr/Min	Latitude	Longitude	Latitude	Longitude	Fished	Time	Fished	Fished
				Deg Min	Deg Min	Deg Min	Deg Min	Min	Zone	(km)	(m)
75	5	30	1240	59 40.0	143 44.0	59 41.0	143 47.0	65	9	7.22	127.4-140.1

TAXON	COUNT			WET WEIGHT (gin)		
	No.	%	Per km	Total	%	Per km

INVERTEBRATES

<i>Notostomobdella</i> sp.	1.0	2.7	0.1	2.0	0.0	0.3
<i>Pecten caurinus</i>	1.0	0.2	0.1	350.0	1.0	48.5
<i>Astarte polaris</i>	90.0	17.6	12.5	900.0	2.5	124.7
<i>Fusitriton oregonensis</i>	4.0	0.8	0.6	400.0	1.1	55.4
<i>Pyrulofusus harpa</i>	1.0	0.2	0.1	100.0	0.3	13.9
<i>Arctomelon stearnsii</i>	1.0	0.2	0.1	180.0	0.5	24.9
<i>octopus</i> sp.	1.0	0.2	0.1	90.0	0.2	12.5
<i>Eualis barbata</i>	8.0	1.6	1.1	56.0	0.2	7.8
<i>Lopholithodes foraminatus</i>	55.0	10.7	7.6	25400.0	70.2	3518.0
<i>Chionoecetes bairdi</i>	45.0	8.8	6.2	5890.0	16.3	818.8
<i>Laqueus californianus</i>	5.0	1.0	0.7	15.0	0.0	2.1
<i>Ctenodiscus crispatus</i>	136.0	26.6	18.8	1360.0	3.8	188.4
<i>Allocentrotus fragilis</i>	13.0	2.5	1.8	520.0	1.4	72.0
<i>Strongylocentrotus droebachiensis</i>	1.0	0.2	0.1	30.0	0.1	4.2
<i>Ophiura sarsi</i>	150.0	29.3	20.8	900.0	2.5	124.7

VERTEBRATES

<i>Atheresthes stomias</i>	249480.0	57.2	34554.0
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TABLE VIII

CONTINUED

TAXON	COUNT			WET WEIGHT (gin)		
	No.	%	Per km	Total	%	Per km
<u>VERTEBRATES</u>						
(continued)						
<i>Hippoglossoides elassodon</i>	-	-		186880.0	42.8	25883.7

COMMENTS*Lopholithodes foraminatus* - 48 males and 7 females

TABLE IX

Tow NUMBER 100; STATION NUMBER 89-A; PERCENT SAMPLED = 100.

Date			Start		Finish		Time	Time	Distance	Depth	
Yr	Mo	Da	Latitude	Longitude	Latitude	Longitude	Fished		Fished	Fished	
			Hr /Min								
			Min	Min	Min	Min	Min	Zone	(km)	(m)	
75	7	12	1455	60 1.0	143 1.0	60 0.	142 55.0	60	9	5.74	67.3-71.0

TAXON	COUNT			WET WEIGHT (gin)		
	No.	%	Per km	Total	%	Per km
<i>Eunoe depressa</i>	1.0	0.2	0.2	1.0	0.0	0.2
<i>Aphrodita</i> sp.	2.0	0.3	0.3	12.0	0.0	2.1
<i>Aphrodita japonica</i>	1.0	0.2	0.2	10.0	0.0	1.7
<i>Nuculana fossa</i>	13.0	2.1	2.3	13.0	0.0	2.3
<i>Pecten caurinus</i>	3.0	0.5	0.5	1050.0	0.9	182.9
<i>Astarte polaris</i>	12.0	2.0	2.1	120.0	0.1	20.9
<i>Natica clausa</i>	3.0	0.5	0.5	36.0	0.0	6.3
<i>Polinices monteronis</i>	2.0	0.3	0.3	80.0	0.1	13.9
<i>Buccinum plectrum</i>	2.0	0.3	0.3	40.0	0.0	7.0
<i>Beringius kennicotti</i>	45.0	7.3	7.8	4950.0	4.3	862.4
<i>Colus halli</i>	2.0	0.3	0.3	36.0	0.0	6.3
<i>Neptunea lyrata</i>	180.0	29.3	31.4	32400.0	28.1	5644.6
<i>Neptunea pribiloffensis</i>	2.0	0.3	0.3	360.0	0.3	62.7
<i>Pagurus ochotensis</i>	39.0	6.3	6.8	3510.0	3.0	611.5
<i>Pagurus aleuticus</i>	24.0	3.9	4.2	2640.0	2.3	459.9
<i>Pagurus kennerly</i>	12.0	2.0	2.1	1320.0	1.1	230.0
<i>Pagurus confragosus</i>	130.0	21.1	22.6	14300.0	12.4	2491.3
<i>Elassochirus tenuimanus</i>	11.0	1.8	1.9	1320.0	1.1	230.0
<i>Elassochirus cavimanus</i>	4.0	0.7	0.7	440.0	0.4	76.7
<i>Labidochirus splendescens</i>	1.0	0.2	0.2	50.0	0.0	8.7
<i>Oregonia gracilis</i>	1.0	0.2	0.2	180.0	0.2	31.4
<i>Hyas lyratus</i>	13.0	2.1	2.3	2340.0	2.0	407.7
<i>Chionoecetes bairdi</i>	103.0	16.7	17.9	46350.0	40.2	8074.9

TABLE IX

CONTINUED

TAXON	COUNT			WET WEIGHT (gm)		
	No.	%	Per km	Total	%	Per km
<i>Pseudarchaster parelii</i>	1.0	0.2	0.2	90.0	0.1	15.7
<i>Luidia foliolata</i>	3.0	0.5	0.5	1350.0	1.2	235.2
<i>Pycnopodia helianthoides</i>	5.0	0.8	0.9	2250.0	2.0	392.0
<u>VERTEBRATES</u>						
<i>Raja binoculata</i>	-	-	-	51250.0	18.3	8928.6
<i>Raja rhina</i>	-	-	-	10430.0	3.7	1817.1
<i>Raja stellulata</i>	-	-	-	24490.0	8.7	4266.6
<i>Gadus macrocephalus</i>	-	-	-	91170.0	32.5	15883.3
<i>Theragra chalcogramma</i>	-	-	-	37190.0	13.3	6479.1
<i>Atheresthes stomias</i>	-	-	-	12700.0	4.5	2212.5
<i>Glyptocephalus zachirus</i>	-	-	-	48080.0	17.2	8376.3
<i>Hippoglossoides elassodon</i>	-	-	-	4980.0	1.8	867.6

COMMENTS

Hermit crabs weighed with shell. Pollutants were not recorded.

TABLE X

TOW NUMBER 89; STATION NUMBER 93-C; PERCENT SAMPLED = 100.

Date Yr Mo Da	Time Hr /Min	Start		Finish		Time Fished Min	Time Zone	Distance Fished (km)	Depth Fished (m)
		Latitude Deg Min	Longitude Deg Min	Latitude Deg Min	Longitude Deg Min				
7 5 7 9	1550	59 51.0	142 3.0	59 50.0	141 57.0	60	9	5.55	81.9-85.5

TAXON	COUNT			WET WEIGHT (gin)		
	No.	%	Per km	Total	%	Per km
<u>INVERTEBRATES</u>						
Actiniidae	2.0	0.3	0.4	180.0	0.1	32.4
<i>Pecten caurinus</i>	290.0	44.6	52.3	101500.0	52.5	18288.3
<i>Cyclocardia ventricosa</i>	1.0	0.2	0.2	4.0	0.0	0.7
<i>Compsomya subdiaphana</i>	1.0	0.2	0.2	4.0	0.0	0.7
<i>Fusitriton oregonensis</i>	1.0	0.2	0.2	70.0	0.0	12.6
<i>Rocinela augustata</i>	1.0	0.2	0.2	1.0	0.0	0.2
<i>Pandalus borealis</i>	1.0	0.2	0.2	4.0	0.0	0.7
<i>Pandalus montagui tridens</i>	6.0	0.9	1.1	50.0	0.0	9.0
<i>Pandalus platyceros</i>	1.0	0.2	0.2	45.0	0.0	8.1
<i>Crangon communis</i>	2.0	0.3	0.4	14.0	0.0	2.5
<i>Argis ovifer</i>	1.0	0.2	0.2	4.0	0.0	0.7
<i>Pagurus ochotensis</i>	1.0	0.2	0.2	90.0	0.0	16.2
<i>Pagurus confragosus</i>	2.0	0.3	0.4	180.0	0.1	32.4
<i>Lopholithodes foraminatus</i>	1.0	0.2	0.2	420.0	0.2	75.7
<i>Chionoecetes bairdi</i>	9.0	1.4	1.6	4050.0	2.1	729.7
<i>Ctenodiscus crispatus</i>	100.0	15.4	18.0	1000.0	0.5	180.2
<i>Pycnopodia helianthoides</i>	190.0	29.2	34.2	85500.0	44.2	15405.4
<i>Ophiura sarsi</i>	40.0	6.2	7.2	240.0	0.1	43.2

TABLE X

CONTINUED

TAXON	COUNT			WET WEIGHT (gin)		
	No.	%	Per km	Total	%	Per km
<u>VERTEBRATES</u>						
<i>Raja stel lulata</i>				4980.0	1.9	897.3
<i>Gadus macrocephalas</i>				20380.0	7.8	3672.1
<i>Theragra chalcogramma</i>				138160.0	52.8	24893.7
<i>Atheresthes stomias</i>				59110.0	22.6	10650.5
<i>Hippoglossoides elassodon</i>				17660.0	6.8	3182.0
<i>Hippoglossus stenolepis</i>				21290.0	8.1	3836.0

COMMENTS

Hermit crabs weighed with shells. *Pycnopodia helianthoides* feeding on *Ophiura sarsi* and *Ctenodiscus crispatus*. Pollutants were not recorded.

TABLE XI

TOW NUMBER 54; STATION NUMBER 94-A; PERCENT SAMPLED = 60.

(All counts and weights are projected to 100% of the sample).

Date				Time	Start		Finish		Time Fished	Time Zone	Distance Fished (km)	Depth Fished (m)
					Latitude	Longitude	Latitude	Longitude				
Yr	Mo	Da		Hr /Min	Deg Min	Deg Min	Deg Min	Deg Min	Min			
7	5	6	3	0950	59 54.0	141 47.0	59 55.0	141 48.0	30	9	2.96	27.3-29.1

TAXON	COUNT			WET WEIGHT (gin)		
	No.	%	Per km	Total	%	Per km
<u>INVERTEBRATES</u>						
<i>Pagurus aleuticus</i>	6.7	50.0	2.3	750.0	20.0	253.4
<i>Chionoecetes bairdi</i>	3*3	25.0	1.1	1500.0	40.0	506.8
<i>Cancer magister</i>	3.3	25.0	1.1	1500.0	40.0	506.8

VERTEBRATES

<i>Theragra chalcogramma</i>	127000.0	14.4	42905.4
<i>Isopsetta isolepis</i>	27200.0	3.1	9189.2
<i>Platichthys stellatus</i>	725750.0	82.5	245185.8

COMMENTS

All female *Cancer magister* had purple eggs with orange eyes. Weights of *Pagurus aleuticus* include their shells.

TABLE XII

TOW NUMBER 53; STATION NUMBER 94-B; PERCENT SAMPLED = 12.

(All counts and weights are projected to 100% of the sample).

Date			Time		Start		Finish		Time		Distance	Depth
Yr	Mo	Da	Hr	/Min	Latitude	Longitude	Latitude	Longitude	Fished	Time	Fished	Fished
					Deg	Min	Deg	Min	Min	Zone	(km)	(m)
7	5	6	3	0730	59	50.0	141	42.0	60	9	5.55	58.2-61.8

TAXON	COUNT			WET WEIGHT (gin)		
	No.	%	Per km	Total	%	Per km
<u>INVERTEBRATES</u>						
<i>Eunephthya rubiformis</i>	0.	0.	0.	3750.0	71.4	675.7
<i>Chionoecetes bairdi</i>	100.0	100.0	18.0	1500.0	28.6	270.3
<u>VERTEBRATES</u>						
<i>Theragra chalcogramma</i>				544250.0	12.6	98063.1
<i>Isopsetta isolepis</i>				215416.7	5.0	38813.8
<i>Platichthys stellatus</i>				3549416.7	92.4	639534.5

COMMENTS

All *Theragra chalcogramma* was approximately 10 cm long. *Platichthys stellatus* stomachs examined - all stomachs were full of three clams, *Yoldia seminuda*, *siliqua sloati*, and *Macoma dextrostera*.

TABLE XIII

TOW NUMBER 78; STATION NUMBER 97-C; PERCENT SAMPLED = 100.

Date				Start				Finish				Time		Distance		Depth	
				Latitude	Longitude	Latitude	Longitude	Fished	Time	Fished	Fished						
Yr	Mo	Da		Hr	/Min	Deg	Min	Deg	Min	Deg	Min	Min	Zone	(km)		(m)	
7	5	7	5	14	10	59	30.0	141	3.0	59	32.0	140	58.0	60	8	5.93	252.9-254.8

TAXON	COUNT			WET WEIGHT (gm)		
	No.	%	Per km	Total	%	Per km
Actiniidae	104.0	0.5	17.5	2630.0	1.1	443.5
Hirudinae	1.0	0.0	0.2	1.0	0.0	0.2
<i>Fusitriton oregonensis</i>	70.0	0.3	11.8	850.0	0.4	143.3
<i>Neptunea pribiloffensis</i>	7.0	0.0	1.2	1040.0	0.4	175.4
<i>Tritonia exsulans</i>	91.0	0.4	15.3	1365.0	5.7	2301.9
Gonatidae	12.0	0.1	2.0	270.0	0.1	45.5
<i>octopus sp.</i>	1.0	0.0	0.2	90.0	0.0	15.2
<i>Pandalopsis dispar</i>	10.0	0.0	1.7	450.0	0.2	75.9
<i>Eualis barbata</i>	1.0	0.0	0.2	4.0	0.0	0.7
<i>Eualis macrophthalma</i>	21.0	0.1	3.5	180.0	0.1	30.4
<i>Crangon communis</i>	21.0	0.1	3.5	140.0	0.1	23.6
<i>Pagurus confragosus</i>	4.0	0.0	0.7	440.0	0.2	74.2
<i>Chionoecetes bairdi</i>	2.0	0.0	0.3	450.0	0.2	75.9
<i>Hippasterias spinosa</i>	1.0	0.0	0.2	220.0	0.1	37.1
<i>Pseudarchaster parelii</i>	16.0	0.1	2.7	1450.0	0.6	244.5
<i>Ctenodiscus crispatus</i>	80.0	0.4	13.5	1350.0	0.5	227.7
<i>Pycnopodia helianthoides</i>	3.0	0.0	0.5	1350.0	0.6	227.7
<i>Brisaster townsendi</i>	21273.0	97.9	3587.4	212730.0	89.6	35873.5
Holothuroidea	2.0	0.0	0.3	90.0	0.0	15.2
<i>Molpadia sp.</i>	2.0	0.0	0.3	90.0	0.0	15.2

TABLE XIII

CONTINUED

TAXON	COUNT			WET WEIGHT (gin)		
	No.	%	Per km	Total	%	Per km
<u>VERTEBRATES</u>						
<i>Squalus acanthias</i>				49370.0	9.2	8325.5
<i>Raja binoculata</i>				41670.0	7.8	7027.0
<i>Sebastes alutus</i>				4070.0	0.8	686.3
<i>Sebastolobus alascanus</i>				81080.0	15.2	13672.8
<i>Atheresthes stomias</i>				138390.0	25.9	23337.3
<i>Glyptocephalus zachirus</i>				101920.0	19.1	17187.2
<i>Microstomus pacificus</i>				82670.0	15.5	13941.0
<i>Platichthys stellatus</i>				35560.0	6.7	5996.6

COMMENTS

Hermit crabs weighed with shell. Pollutants were not recorded.

TABLE XIV

TOW NUMBER 70; STATION NUMBER 99-D; PERCENT SAMPLED = 100.

Date Yr Mo Da	Time Hr /Min	Start		Finish		Time Fished Min	Time Zone	Distance Fished (km)	Depth Fished (m)
		Latitude Deg Min	Longitude Deg Min	Latitude Deg Min	Longitude Deg Min				
7 5 7 2	1635	59 25.0	140 29.0	59 25.0	140 32.0	60	8	5.55	141.9-154.7

TAXON	COUNT			WET WEIGHT (gin)		
	No.	%	Per km	Total	%	Per km
<u>INVERTEBRATES</u>						
<i>Actiniidae</i>	8.0	0.1	1.4	1810.0	0.2	326.1
<i>Euphrosine hortensis</i>	1.0	0.0	0.2	1.0	0.0	0.2
<i>Crucigera irregularis</i>	1.0	0.0	0.2	1.0	0.0	0.2
<i>Aphrodita japonica</i>	14.0	0.3	2.5	630.0	0.1	113.5
<i>Fusitriton oregonensis</i>	26.0	0.5	4.7	1990.0	0.2	358.6
<i>Neptunea lyrata</i>	20.0	0.4	3.6	2260.0	0.3	407.2
<i>Pyrulofusus harpa</i>	14.0	0.3	2.5	3170.0	0.4	571.2
<i>Arctomelon stearnsii</i>	14.0	0.3	2.5	1580.0	0.2	284.7
Dorididae	80.0	1.5	14.4	14490.0	1.7	2610.8
<i>Octopus sp.</i>	26.0	0.5	4.7	2340.0	0.3	421.6
<i>Pandalus montagui tridens</i>	429.0	8.0	77.3	340'0.0	0.4	612.6
<i>Spirontocaris arcuata</i>	14.0	0.3	2.5	90.0	0.0	16.2
<i>Argis ovifer</i>	102.0	1.9	18.4	510.0	0.1	91.9
<i>Elassochirus cavimanus</i>	13.0	0.2	2.3	580.0	0.1	104.5
<i>Acantholithodes hispidus</i>	1.0	0.0	0.2	10.0	0.0	1.8
<i>Lopholithodes foraminatus</i>	40.0	0.7	7.2	16800.0	2.0	3027.0
<i>Munida quadrispina</i>	45.0	0.8	8.1	240.0	0.0	43.2
<i>Oregonia gracilis</i>	10.0	0.2	1.8	1800.0	0.2	324.3
<i>Hyas lyratus</i>	140.0	2.6	25.2	12680.0	1.5	2284.7
<i>Chionoecetes bairdi</i>	20.0	0.4	3.6	2260.0	0.3	407.2

TABLE XIV

CONTINUED

TAXON	COUNT			WET WEIGHT (gin)		
	No.	%	Per km	Total	%	Per km
<i>Chorilia longipes</i>	10.0	0.2	1.8	600.0	0.1	108.1
<i>Dipsacaster borealis</i>	14.0	0.3	2.5	630.0	0.1	113.5
<i>Ceramaster patagonicus</i>	30.0	0.6	5.4	2710.0	0.3	488.3
<i>Pseudarchaster parelii</i>	200.0	3.7	36.0	18120.0	2.1	3264.9
<i>Henricia aspera</i>	653.0	12.2	117.7	59160.0	6.9	10659.5
<i>Diplopteraster multipes</i>	78.()	1.5	14.1	11770.0	1.4	2120.7
<i>Crossaster papposus</i>	40.0	0.7	7.2	3620.0	0.4	652.3
<i>Lophaster furcilliger</i>	4.0	0.1	0.7	450.0	0.1	81.1
<i>SoLaster dawsoni</i>	40.0	0.7	7.2	9060.0	1.1	1632.4
<i>Allocentrotus fragilis</i>	41.0	0.8	7.4	1640.0	0.2	295.5
<i>Strongylocentrotus droebachiensis</i>	92.0	1.7	16.6	2760.0	0.3	497.3
<i>Gorgonocephalus caryi</i>	20.0	0.4	3.6	4530.0	0.5	816.2
<i>Ophiura sarsi</i>	400.0	7.4	72.1	900.0	0.1	162.2
Cucumariidae	2600.0	48.4	468.5	650000.0	76.2	117117.1
<i>Halocynthia aurantium</i>	130.0	2.4	23.4	20300.0	2.4	3657.7

VERTEBRATES

<i>Raja binoculata</i>	15400.0	3.2	2774.8
<i>Raja stellulata</i>	10870.0	2.3	1958.6
<i>Gadus macrocephalus</i>	78140.0	16.4	14079.3
<i>Sebastolobus alascamus</i>	94220.0	19.8	16976.6
<i>Sebastes alutus</i>	27180.0	5.7	4897.3
<i>Atheresthes stomias</i>	219700.0	46.2	39585.6
<i>Glyptocephalus zachirus</i>	30500.0	6.4	5495.5

COMMENTS

Hermit crabs weighed with shell. *Crucigera* irregulars present on snail shell Pollutants were not recorded.

FINAL REPORT

Research Unit #19
March 1976 - September 1978

Alaska Marine Environmental Assessment Project

FINFISH RESOURCE SURVEYS IN NORTON SOUND AND KOTZEBUE SOUND

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SUMMARY

These studies have included an evaluation of the subsistence use of Pacific herring and other fishery resources to coastal residents in Norton Sound and Kotzebue Sound. In addition, the spatial and temporal distribution of fishery resources in the nearshore coastal waters of Norton Sound was investigated. Pacific herring are used to a lesser degree for subsistence purposes by coastal residents in Kotzebue Sound than by those in Norton Sound. Extent of use is influenced by herring abundance, harvest of marine and large terrestrial mammals and employment opportunities such as commercial salmon fishing.

Important herring spawning areas consist of exposed rocky headlands, shallow bays, lagoons or inlets. Spawning is associated with ice breakup of the Bering Sea, occurring in late May-early June in south Norton Sound, commencing progressively later in a northward direction; as late as August in parts of Kotzebue Sound. Herring populations north of the Yukon River are relatively small in comparison to those of the southern Bering Sea. Independent stocks of Pacific herring occur north of Norton Sound and spawn, overwinter and rear in shallow lagoons and embayments along the Seward Peninsula. A relatively small percentage of the coastline is used for spawning by herring stocks and the integrity of these areas must be maintained to insure continued use of this important resource. Contamination of important spawning, rearing and/or overwintering areas from petroleum related activities could destroy one or more year classes, resulting in either a general weakening and decline in populations or possible elimination of an entire population, depending upon the severity and extent of pollution.

More than 15,000 finfish representing 39 species and 15 families, were captured in nearshore coastal waters of the study area in 1976-77. Various cottids were included in this catch but were only identified to family (Cottidae). The 38 species identified were represented by 19 marine, 10 anadromous and 9 freshwater forms. Percent composition among these forms was similar in 1976 and 1977 in areas examined. At least 90% of the anadromous species, 75% freshwater species and 30% marine species are utilized for subsistence purposes by coastal residents. Approximately 60% of the anadromous species, 10% freshwater species and, at present, 5% marine species are harvested commercially by domestic fisheries. Pacific sand lance (Ammodytes hexapterus), juvenile pink (Oncorhynchus gorbuscha) and chum salmon (O. keta), saffron cod (Eleginus gracilis) and osmerids were among the most abundant species captured. Saffron cod, starry flounder (Platichthys stellatus), coregonids and osmerids were among the most frequently encountered fishes. Both frequency of occurrence and abundance varied spatially and temporally in all areas examined.

Some concerns related to petroleum exploration and development and the potential impact of oil spills on the fishery resources throughout the study area are discussed. A major concern is the absence of data on distribution, relative abundance, range, age structures, etc. of fishery resources during the ice covered months. A second concern is the lack of information available on fishery resources which utilize the Yukon River Delta. This is considered as possibly the single most important

ecosystem in our area and potentially the most vulnerable to disruption from either acute or chronic pollution problems. The deep water harbor of Port Clarence is also discussed as an area where further studies are needed to ensure proper planning and development of petroleum related activities in this area.

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INTRODUCTION

This completion report covers studies conducted under Research Unit (R. U.)19, formerly 19e, FINFISH RESOURCE SURVEYS IN NORTON SOUND AND KOTZEBUE SOUND. The study was supported by the Bureau of Land Management (BLM) through interagency agreement with the National Oceanic and Atmospheric Administration (NOAA), under which a multi-year program responding to needs of petroleum development of the Alaskan continental shelf is managed by the Outer Continental Shelf Environmental Assessment Program (OCSEAP) office. The period of fieldwork includes March 1976 through November 1977.

Work was initially funded in March 1976 for \$146,825 as an extension of R.U.19, HERRING SPAWNING SURVEYS IN THE SOUTHERN BERING SEA. Additional funding for fiscal year (FY) 1977 (October 1, 1976 through September 30, 1977) consisted of \$250,825, of which \$100,000 was designated for large vessel sampling of the offshore waters of Norton Sound and Kotzebue Sound. Final funding (\$60,000) was made available for FY78 to allow completion of 1977 field sampling through freezeup and for preparation of this report. Total funding level for this project was \$457,650.

Stimulus for these investigations is provided by proposed offshore leasing of Alaska's continental shelf for oil exploration and development, and the current lack of knowledge concerning the range, distribution, seasonal occurrence, relative abundance and life history characteristics of important fishery resources occurring throughout the study area. These data are necessary to provide information for predicting and mitigating impacts of potential petroleum related activities on coastal fishery resources within the study area. Specific objectives include the following:

1. Determine the spatial and temporal distribution, species composition and relative abundance of pelagic finfish in the coastal waters of Norton Sound east of 166° W. Longitude.
2. Determine the timing and routes of juvenile salmon migrations as well as examine age and growth, relative maturity and food habits of important species in Norton Sound east of 166° Longitude.
3. Determine the spatial and temporal distribution and relative abundance of spawning populations of herring and other forage fish within the study area.
4. Monitor egg density, distribution and development and document types of spawning substrates of herring and other forage fish species.
5. Monitor local resident subsistence utilization of the herring fishery resource.

To accomplish the task outlined above, the following studies were conducted:

- Subsistence fishery utilization survey of coastal residents. Surveys were primarily confined to FY76 with minimal effort in FY77.
- Spawning herring surveys. This consisted primarily of aerial surveillance of the coastline, apart from areas where nearshore finfish studies were being conducted. Aerial surveys were complemented by ground surveys at the latter locations.
- Pelagic finfish surveys. Both nearshore and offshore surveys were made. Nearshore sampling was confined to Norton Sound while attempts were made to sample offshore waters of both Norton Sound and Kotzebue Sound.

Pacific herring (Clupea harengus pallasii) are discussed at length in this report not **only** because a major portion of this R.U. was designed to investigate this species, but also because of the growing concern for this species in the eastern Bering Sea. Domestic interest in this species has risen dramatically in the past several months with implementation of the 200 mile fisheries and management conservation zone. Lack of biological knowledge of this species and apparent over-exploitation of eastern Bering Sea herring stocks by foreign fisheries has made it the focal **point** of much discussion.

Information gained on the relative abundance and seasonal distribution of pelagic fishery resources and their subsistence use throughout the study area is not complete, but nevertheless, is of considerable scientific **value**. Subsequent work **will** no doubt supplement and improve the existing data base and insure proper planning for oil and gas exploration and development, thus providing protection to valuable resources.

CURRENT STATE OF KNOWLEDGE

Knowledge of fishery resources in the northern Bering Sea and Kotzebue Sound is quite limited. Most available information is contained in records kept by the Alaska Department of Fish and Game (ADF&G). The bulk of this data deals with species of Pacific salmon indigenous to the study area, of which chum salmon (Oncorhynchus keta) are the most abundant. Most of this information concerns run timing and magnitude, age, size and sex relationships and spawning distribution of **adult** returns. Virtually nothing is known in regards to the relative abundance, distribution, migrational patterns and habits of juvenile salmon after entering the marine environment.

Other species common to the fresh water and coastal marine habitats in the study area are: **sheefish** (Inconnu, Stenodus leucichthus), several species of whitefish (Coregonidae), Arctic char (Salvelinus alpinus), lake trout (Salvelinus namaycush), grayling (Thymallus arcticus), burbot (Lota lota luptura), suckers (Catostomidae), sculpins (Cottidae), blackfish (Dallia pectoralis), sticklebacks (Gasterosteidae), lampreys (Petromyzontidae), smelt (Osmeridae) and several species of cod (Gadidae), flatfishes (Pleuronectidae), crabs, shrimp and molluscs (Cunningham 1975). Fifty-two fish species were captured and identified in August 1959 in the

Chukchi Sea/Kotzebue Sound area under bioenvironmental investigations of Project Chariot (Alverson & Wilimosky 1966). Most of the forms were benthic or demersal with the pelagic element limited to about eight species. Nine freshwater species were identified. Among the catches were an estimated 1,000 herring captured in a single gillnet set made at Cape Thompson. It was stated that small catches of juvenile smelt were often experienced in midwater sets below the thermocline.

Field sampling with variable mesh gillnets by Alt (1971) in the Port Clarence area in July 1970 resulted in 23 species of fish of which nine were marine. Herring were captured in Imuruk Basin and the lower Agiapuk Basin. Six nights of gillnet fishing in the Agiapuk River in 1971 resulted in nine species, of which least cisco (Coregonus sardinella) were the most abundant (Alt 1972). Herring were again included in the catch.

Alt (1971, 1972) also discussed spawning populations and domestic use of sheefish on the Koyuk River, Kobuk River and in the Selawik Lake - Hotham Inlet area. Herring, ranging in size from 115-160 mm in total length, were reported as comprising the major food item (the only identifiable species) in sheefish captured in Hotham Inlet in late November 1963 (ADF&G files).

Pacific herring and other fishery resources in the study area are known to be an important food fish for coastal residents, but the magnitude and importance of this harvest has not been fully documented. Zagoskin (1967) mentioned the importance of herring subsistence utilization by resident natives as early as the mid 1800's. The first actual biological studies on Bering Sea herring were conducted by Rounsefell (1930). Mention is made several times in his report of herring vertebrae counts taken at Unalaska and Golovin Bay (Norton Sound). Documentation of several life history parameters of herring are included in his report as well as the condition of the fishery in Alaska.

The herring fishery in the early portion of the 20th Century centered around salt curing and later declined because of poor marketing conditions arising from foreign competition. Rounsefell indicated that the earliest American commercial effort on Bering Sea herring took place in the early part of this century at Golovin Bay, "...since before 1909". Early records (Pacific Fisherman 1917-1942) indicate that about 6.1 million pounds of fall herring were commercially processed in Norton Sound from 1916 to 1941, of which 98.6% was from Golovin (Table 1). This figure is based upon 250 pounds of herring packed per barrel (Andersen 1945; Wigutoff 1950).

Rounsefell (1930) also pointed out that the first extensive commercial herring fishery existed in Western Alaska in 1928 when about one-half of the Central Alaska purse seine fleet fished in Unalaska in the Aleutian Islands. This fishery ended in 1946. Domestic commercial effort on herring in the north Bering Sea (Norton Sound) resumed on an experimental basis in 1964 near Unalakleet and has continued on a sporadic basis ever since (Table 2). This fishery is on spring herring for sac roe extraction in contrast to the earlier fall fisheries for a salt cured product.

Barton **et al.** (1977) points out that herring may be a commercially exploitable resource **of** potential benefit to coastal residents of western Alaska as well as a potential major international food source. Foreign fishing of eastern Bering Sea herring stocks began in 1961 after Soviet exploratory trawlers located large concentrations of wintering herring northwest of the **Pribilof** Islands. The Japanese entered the trawl fishery on the winter grounds in 1964 and also began a **gillnet** fishery east of 175° West longitude in 1968 (Low 1976, not seen by author; cited from **Wespestad** 1978). Japanese and Soviet fleets have harvested some 45,000 metric tons (**m.t.**) of herring annually in the eastern Bering Sea from 1970-1976 (North Pacific Fisheries Management Council 1977, NPFMC). The bulk of this harvest has come from **two trawl** fisheries which operate along and inside the 200 meter line between the **Pribilof** Islands and **St. Matthew Island** during the winter-spring months. The Japanese **gillnet** fishery has operated in the past in the nearshore waters from April to June, from Bristol Bay to Norton Sound, until 1977 when those coastal waters were closed by the Secretary of Commerce to protect native subsistence fisheries. **Dudnik and Usol'tsev** (1972) believed the **trawl** harvests were on stocks which reproduce along the coast from **Unimak Pass** to Norton Sound.

Combined harvest information for the winter trawl fishery by both Japanese and Soviet fleets **is only** available since 1967, although Japanese **trawl** and **gillnet** catches have been reported since 1964 (Table 3) (**ADF&G 1977**). Available catch data indicates that peak production occurred in 1968-69 when 128,000 **m.t.** were harvested by both the **trawl** and **gillnet** fisheries. Production has steadily declined since that time.

The Japanese began their gillnetting in **1968** in Norton Sound (north of 63° North latitude and east of 167° West longitude) with three vessels ranging from 46 to 61 meters in length (**ADF&G 1968**). Effort was concentrated about 20 km offshore in the area between **St. Michael** and **Golovin** for several days. Japanese **gillnetting** effort as well as peak catches occurred in 1969 (Table 4). A fleet **of** approximately 40 vessels operated in Norton Sound during the spring of 1969 (**ADF&G 1969**). The **fleet** was composed of approximately 10 **longliner** type vessels (37 to 55 meters) that arrived on May 19 and operated gillnets, processed and held their own catch. On the first **of** June two factory ships arrived accompanied by 24 to 27 **gillnetters** all in the 26 to 27 meter class. Three stern trawlers rounded out the Japanese fleet in 1969. The U.S. Coast **Guard** apprehended two Japanese **gillnetters** on June 7, 1969 which were fishing within the continual zone in the vicinity of **St. Michaels** (**ADF&G 1969**). A total of 20 mt of herring was aboard the two apprehended vessels. Most herring examined consisted of spawned out males. The **total** reported 1969 Japanese **gillnet** herring catch in Norton Sound amounted to 1,270 metric tons. This was the largest herring catch by Japanese fleets in Norton Sound from 1968 through 1976.

The Republic of Korea (**ROK**) operated a **small** trawl fishery for herring between **Kuskokwim Bay** and Norton Sound in 1973 and 1974.

Herring "are known to spawn in intertidal and shallow **subtidal** zones in the study area. Developing eggs and larvae are therefore **highly** susceptible to surface-born pollution. These fish and their spawn constitute one of

the fundamental sources of food for many species of fish, mammals and birds.

Apart from present investigations, the most recent studies dealing with the distribution and relative abundance of fishery resources in the northern Bering Sea and southeastern Chukchi Sea was a six week survey conducted in 1976 by the National Marine Fishery Service (NMFS) under the auspice of OCSEAP/R.U.175. Results of the survey defined the distributions and centers of abundance of several finfish and shellfish species. In addition, standing stock estimates and species composition of demersal fauna were determined. Estimates of biological characteristics, including size and age composition, length and weight relationships, and growth characteristics were provided for dominant fish species.

These foregoing studies comprise the investigator's knowledge of fishery research in the north Bering Sea and Kotzebue Sound area, with the exception of cruise reports by various American and foreign agencies, which list simple occurrence.

STUDY AREA

The study area includes all coastal waters of western Alaska extending north from the Yukon River Delta to Point Hope (Figure 1). The coastline of this area totals 2,496 km (1,551 miles). Subsistence utilization surveys were conducted throughout the entire study area while spawning herring investigations included the coastal waters from the Yukon River to Eschscholtz Bay in Kotzebue Sound. The study area for nearshore finfish surveys consisted of the coastal waters from the Yukon River to Port Clarence, while offshore studies included both Norton Sound and Kotzebue Sound.

SOURCES, METHODS AND RATIONALE OF DATA COLLECTION

Several news releases via local radio stations (Nome) and newspapers were made prior to and throughout the course of the 1977 sampling season. These releases explained the purpose of the Outer Continental Shelf (OCS) program, informed listeners to 1977 field projects being conducted and solicited local information on fishery resources. Releases were made in March, June, July, August and September.

Subsistence Utilization Surveys

The only information obtained pertaining to subsistence use of fishery resources in 1977 was associated with aerial herring surveys conducted along the coast. Residents from five Seward Peninsula villages were questioned during the course of these surveys about herring and the status of fall runs and their importance to subsistence use. Several preserved specimens of different fish species were taken on flights for species verification by local residents to insure information was obtained for appropriate species.

Herring Aerial Surveys

The entire coastline of the study area was divided into census areas delineated by prominent geographical features prior to field investigations (Table 5). These divisions were made to facilitate transcribing aerial survey data onto a data management format with keypunching output to be later submitted to the National Oceanic Data Center (NODC) for archiving. At least two aerial reconnaissance surveys were to be attempted of the entire study area within the range of estimated spawning dates. Aerial surveillance of primary spawning areas was conducted as frequently as possible beginning with the onset of ice breakup in Norton Sound. The purpose of the surveys was a dated continuum on location, timing and relative abundance of spawning populations of herring and other schooling fish species.

Aerial surveys were conducted from chartered aircraft (single engine, fixed-wing) at altitudes ranging from 75-500 m and air speeds of about 160-260 km/hr. Portable tape recorders were used to record aerial survey data and information transcribed daily onto aerial survey data management forms. Polaroid sunglasses were worn to reduce sunglare and enhance water depth visibility.

Following is a listing of data parameters recorded during each survey:

1. Observer, type aircraft, speed, altitude and time.
2. Weather and sea conditions.
3. Species identity and location of fish schools.
4. Number and surface area estimates of fish schools.

The relative abundance of fish was estimated by subjectively categorizing schools into one of three arbitrary groups: 1) small schools (estimated surface area of less than 50 m²); 2) medium schools (surface area estimates between 50-450 m²); and 3) large schools (estimated to be greater than 450 m²). These same categorizations were employed under Research Unit 19 in the southern Bering Sea (Barton et al. 1977).

Every attempt was made to properly identify schools of fish observed from the air. This was done by OCS crews already present in an area sampling the nearshore waters with various types of fishing gear. Return flights to selected villages were also made and trips made by rubber raft along the coast to collect samples from fish observed in that area. Where fish could not be captured, Alcids and Larids were collected when possible for stomach analysis.

Photographs (color slides) utilizing a polarizing filter were made of fish schools and spawn (milt) when possible to assist in determining surface area estimates. Major emphasis on photography in 1977 was to obtain high altitude photographs during the peak of spawning in major areas as opposed to 1976 aerial photographs which were made of as many schools of fish and spawn as possible. All photographs were made with a handheld 35mm camera. The altitude, film and frame numbers were recorded on aerial survey forms for later identification. The location of the

photographed target was recorded on United States Geological Survey (USGS) topographical maps and a corresponding number entered by its location signifying the frame number of the photograph for later analysis.

Nearshore Finfish Surveys

Pelagic fish sampling of the nearshore waters (0-6 meters) was restricted to the Yukon River, Norton Sound and Port Clarence in 1977. Sampling was based from four field camps: **Unalakleet**, **Golovin**, Teller and the Anuk River (tributary to the Yukon River).

Unalakleet

A three man crew established a base camp in **Unalakleet** on May 27. The **nearshore** waters of eastern Norton Sound were sampled from May 30 through June 20 and from July 16 through August 10. The sampling area extended north from **Unalakleet** approximately 65 km to Cape **Denbigh** and south from **Unalakleet** for a distance of about 85 km to Cape **Stebbins**. A seven meter (22 foot) open skiff was used, equipped with fishing gear consisting of variable mesh **gillnets**, beach seines, dipnets and castnets. Both floating and sinking variable mesh **gillnets** were used. All **gillnets** were multifilament nylon and consisted of six 7.6 m panels with the following stretch mesh sizes: 25, 38, 51, **64**, **76** and 102 mm. The nets were 46 m long by three meters deep. Sixty-one meter beach seines of 3.2 mm mesh were fished. Seines tapered from three meters in the center to one meter at either end. One beach seine haul and two **gillnet** sets were made at each sample station when possible. An onshore set was made with a floating **gillnet** and an offshore set was made with a sinking **gillnet**. Sampling stations held consistent with those established in the 1976 field season.

Records were kept of the time each **gillnet** was set and retrieved and depth and distance from shore for offshore sets. Other data recorded included weather conditions, surface water temperatures, escapement and beach type. Depth was determined with a Ross depth sounder, while distances were estimated visually.

Sampling with dipnets and castnets was conducted randomly between established sampling stations, primarily for species composition of schools of fish observed in areas away from established sample locations.

Golovin

A base camp was established in **Golovin** on May 25 from which a two man crew conducted sampling operations. Sampling was conducted from June 9 through July 20 and from August 19 through October 21 from a five meter (17 foot) open skiff. The sampling area included coastal waters inside **Golovin** Bay and west from **Rocky Point to Bluff**. Sampling techniques and gear types were the same as those of the **Unalakleet** crew.

Port Clarence

A two man crew stationed at Teller was responsible for sampling Port

Clarence, **Grantley** Harbor and **Imuruk** Basin. Camp was established on June 25 and sampling conducted from breakup (June 27) until freezeup (October 12). Permanent sample stations were selected and fished after a reconnaissance of the study area. Sampling design and gear types were consistent with those of other Norton Sound crews.

Anuk River

A two man crew was relocated to Emmonak (south mouth of the Yukon River) on May 18 to prepare and assemble sampling gear for this field project. The crew departed Emmonak on June 4, shortly after ice breakup in the Yukon River and traveled upriver to the confluence of the Anuk River (101 km upriver from Flat Island). A field camp was established about one mile upstream on the Anuk River from which sampling operations were conducted (Figure 2).

Adult fall chum salmon stocks in the Yukon River have been found to separate on their upstream migration by river bank (**Mauney**, 1976). It was **felt** that a similar separation by river bank may also apply to smelting juvenile **salmon** in the spring months, since most of the major salmon spawning tributaries drain from the north side. Information concerning the timing, distribution and migration routes of juvenile salmon through the Yukon River Delta to the Bering Sea would be extremely valuable because of potential petroleum development in that area. Consequently, the two man crew stationed on the Anuk River sampled transects of the main Yukon River just below the confluence of the Anuk River. This section was chosen because of its restricted single channel as opposed to other sections of the **lower** Yukon River which are often extremely braided, very wide and characterized by sandbars.

The crew was equipped with a hand purse seine 46 m long by seven meter deep (3.2 mm bar mesh). The center section was eight meters in length and had two outer 11.5 m sections of 13 mm bar mesh. Eight seine stations were established across the Yukon River at the sampling site. A series of seine sets were made daily across the river channel at each sample station. Fishing stations were rotated daily beginning at first one side of the river and then the other. The primary objective was to observe smelt timing and distribution at the sample site as well as collect age and length data by species. Surface water temperatures and fluctuations in the Anuk River were recorded daily at 12 o'clock noon. Sampling occurred from June 7 through July 7, 1977.

Catch Sampling and Data Analysis

Catch sampling by nearshore pelagic **finfish** crews included the following:

1. Total catch monitoring by species, gear type and station for each set made.
2. Fork length measurements of not more than 120 fish of each species excluding herring, captured per set by gear type.

3. Standard length measurements of not more than 180 herring, relative maturity, sex and age for each set by gear type. The relative maturity index is shown in Table 6.
4. No length measurements or **scales** were taken from adult salmon.
5. Length and scale sampling from all juvenile salmon captured except that scales were not taken from pink (Oncorhynchus gorbuscha) and chum salmon. Scales were mounted on glass slides for later age analysis.

Catch sampling for the Anuk River project consisted of the following:

1. The total catch by species. was recorded for each seine haul by station number and date.
2. A maximum of 40 juvenile king salmon (Oncorhynchus tshawytscha) was sampled daily for lengths and scales. A minimum of four fish per seine haul for any given day was always collected.
3. A maximum of 12 coho (Oncorhynchus kisutch) and chum salmon each was sampled daily for scales.
4. A maximum of 40 lengths per seine haul of juvenile salmon other than pinks and king were taken daily.
5. No lengths or **scales** were collected from adult salmon.

All herring were aged by counting annual rings on scales. Reid (1971a) pointed out that new **annuli** of herring scales appear near the time of spawning. He stated, "For convenience in age designation, April is used as the birth date for Alaska herring, although spawning ranges from **early** March to late June." The birth date for herring in our study area could be considered about May or June since spawning occurs on the average, significantly later than in more southern areas of Alaska and in Canada. Consequently, some adjustment to age designation in 1977 was made as herring were captured in both the spring spawning periods as well as just prior to freezeup in some areas.

Herring captured prior to August 1 were aged by counting all annuli plus the outside edge of the scale as shown in photographs 33 through 37. Herring captured after August 1 were also aged by counting annuli but the outside edge of the scale was not included, since it was assumed that some significant summer growth was present in the fall months. This is consistent with methods used in R.U. 175 (Wolotira et al. 1977). All herring scales were aged by not less than two (sometimes three) experienced ADF&G herring biologists.

This interpretation of the characteristics of herring scale growth closely follow results obtained by Rummyantsev and Darda (1970). They stated, "statistical processing. . . showed that in August 50% of the herrings (of the eastern Bering Sea) had no or very little growth increments on their scales; in September it was 14%, in October 17% of the fish."

Herring stomachs were collected along the west coast of Alaska in the spring of 1976 as part of RU 19 and RU 19e. Data analysis was carried out by Mr. Lee Neimark, Institute of Marine Science (IMS), University of Alaska, Fairbanks. Contents from stomachs that were collected on a single date and station were combined into a single sample. Each food item was identified and counted. Where several stomach contents were combined the contents were placed into a measured amount of water and a five mm random aliquot sample taken with a Stemple pipet. Each item in the five mm sample was counted and results corrected for the average item per stomach. The percent content of each food item identified was estimated by visual inspection of each stomach. The three areas where samples were collected were the Togiak area of Bristol Bay, Yukon-Kuskokwim River Delta area (Goodnews Bay, Nelson Island, Hooper Bay) and Norton Sound (Golovin Bay, Unalakleet, St. Michaels Bay).

Foreguts from 23 species of fish were collected along the eastern coast of Norton Sound from June 17 through September 1, 1976. These samples were also sent to the IMS where they were examined by Mr. Neimark. Methods of analysis can be found in Neimark et al. (1978).

Catches of larval fish were tentatively identified in the field by samplers and later submitted to the NMFS, Northwest and Alaska Fishery Center in Seattle for verification.

The study area was divided into several sections for ease in reporting pelagic fish survey results (Figure 3): Golovin Bay (Area A), Cape Denbigh to Egavik (Area B), Egavik to Tolstoi Point (Area C), Tolstoi Point to Cape Stebbins (Area D), Fish River (Area E), Bluff to Rocky Point (Area F), Grantley Harbor (Area G), Port Clarence (Area H), and Imuruk Basin (Area I). Although as many areas were not sampled in 1976, divisions are consistent for yearly comparisons between 1976 and 1977.

The field season was divided into nine 2-week sampling periods in which catch results were examined by species and gear type:

1. June 7 through June 21.
2. June 22 through July 6.
3. July 7 through July 21.
4. July 22 through August 6.
5. August 7 through August 21.
6. August 22 through September 6.
7. September 7 through September 21.
8. September 22 through October 6.
9. October 7 through October 21.

Herring data are often grouped as follows in comparing results:

Spring (breakup) - Sample Periods 1-3 (June 7 - July 21)

Summer - Sample Periods 4-6 (July 22 - September 6)

Fall (freezeup) - Sample Periods 7-9 (September 7 - October 21)

Offshore Finfish Surveys

A 33 m commercial vessel (M/V Royal Atlantic) was chartered in 1977 to fish preselected offshore **gillnet** and surface townet stations in Norton Sound and Kotzebue Sound (Figure 4). Each sample grid represents approximately 375 square kilometers. The study region exists as an area of proposed oil exploration where various resources used for commercial and subsistence fishing occur. Two cruises were planned with the first beginning in Norton Sound immediately after breakup followed by a sampling round of Kotzebue Sound and then a second round of Norton Sound. The Royal Atlantic departed Dutch Harbor for Norton Sound on June 19 and the charter terminated in Dutch Harbor on July 14. A two man crew assisted in all fishing operations during the charter period.

Gillnetting Studies - Large Vessel

A series of variable mesh multifilament **gillnets** secured end to end to form one long net were fished daily at preselected stations. **Gillnets** were allowed to soak overnight from 8 to 10 hours. A set was made each evening and retrieved the following morning.

Two sizes of variable mesh nets were used for this sampling design:

1. Thirty-eight by 5.5 m consisting of five 7.6 m panels of the following stretch mesh sizes (25, 38, **51**, 64 and 76 mm).
2. Twenty-three by 5.5 m consisting of three 7.6 m panels of the following stretch mesh sizes (102, 114 and 133 mm).

At least nine of the smaller mesh paneled nets were secured end to end to form one long net (411 m). The larger mesh panel nets were not fished during the early part of the cruise to minimize adult salmon catches. Target species were juvenile salmon and herring. **Gillnets** were either secured in place overnight by anchors and buoys *or else* allowed to drift by tacking one end of the net to the vessel. They were retrieved with a hydraulic **gillnet** drum onboard the vessel.

Townetting Studies - Large Vessel

Surface townetting was conducted at preselected stations with a 3x3x9 m townet equipped with a rigid frame. The cod end of the net consisted of 1.6 mm mesh webbing. Each tow was 30 minutes in duration at a speed of two to three knots. All tows were conducted in hours of daylight.

Catch Sampling and Data Analysis

The total catch by species and panel size was recorded for each **gillnet**

set. All species of salmon were measured (fork length for juveniles and mid-eye to fork of tail for adults) and scales collected for later age analysis. All herring were weighed, sexed, scale sampled, measured (standard length) and examined for relative maturity. The total weight of each species captured per set was also recorded. Tow samples were processed in the same manner as gillnet samples.

RESULTS

Subsistence Utilization Surveys

Surveys to determine subsistence utilization of fishery resources during the course of these OCS investigations were conducted only during the 1976 field season. Emphasis was directed toward obtaining information on herring utilization by village throughout the study area with other fishery resource use documented as possible. Results of the 1976 surveys can be found in Barton (1977). Information collected in 1977 is included in the discussion section of this paper since effort was primarily directed toward obtaining information on fall herring runs and winter distribution and use. No subsistence surveys, per se, were conducted in 1977. Information was solicited only in villages on the Seward Peninsula: Golovin, Teller, Shishmaref, Deering and Buckland.

Herring Aerial Surveys

A total of 25 individual aerial surveys were flown throughout the study area from June 9 through October 28, 1977 (Stuart Island/Cape Stebbins to Choris Peninsula/Eschscholtz Bay) (Figure 5). Aerial surveillance was initiated with the onset of ice breakup in Norton Sound and intensified during peak herring spawning activities along the coast. Surveys included 60 hours of airtime, 8,010 km (4,977 miles) of coverage and 24 survey days. Coverage of southern and eastern Norton Sound was intensified throughout mid-July, while intensive coverage of the Seward Peninsula occurred from mid-July on. A total of 480 fish schools were counted throughout the season with the following distribution of counts: 192 schools from Cape Stebbins to Cape Nome; 109 schools from Nome to Cape Prince of Wales; and 179 schools from Cape Prince of Wales to Pt. Garnet (Table 7). In addition, spawn (milt) was observed on possibly three occasions.

Most surveys were flown on an opportunistic basis, particularly after mid-July, due to inclement weather and/or water conditions. Survey conditions were exceptionally good from early June (after breakup) until the first weather front moved into the study area on July 23. Foul weather and extremely bad smoke conditions created from tundra fires hindered surveys for nearly a month until mid-August. From this time on, fall storms were frequent (strong winds especially) throughout the study area. Storms left coastal water extremely turbid causing poor to unacceptable survey ratings. As the season progressed into September, blowing snow and near whiteout conditions hindered and finally terminated aerial surveillance of the study area in October.

Cape Stebbins to Unalakleet

The only observation of schooled fish made along the coast from Cape

Stebbins to Unalakleet in 1977 was on June 22 when a single small school was observed about ten meters from shore near Black Point. Earlier surveys were conducted in this area on June 9, 15 and 17 but no schooled fish were observed.

Unalakleet to Cape Denbigh

Seven surveys were flown along the coastal waters from Unalakleet to Point Dexter (north side of Cape Denbigh) from June 9 through July 21. The first observations of herring were made on June 14 when 22 schools were seen around the Cape Denbigh Peninsula. Two small schools were located on the south side of the Cape while 18 small and two medium schools were observed from the Cape to Point Dexter. No spawning was observed. Herring were again observed the following day; six schools near Point Dexter, six schools immediately south of Cape Denbigh, 30 schools between Shaktoolik River and the village of Shaktoolik and three more small schools observed near Egavik.

Peak aerial counts along this section of the study area occurred on June 17. Fifty-four schools of herring were counted between Cape Denbigh and Point Dexter and three schools were located just south of the Cape. Schools were never observed farther than 300 meters from shore and all were dark green to blue in color and ball-shaped. No spawning (bands of fish or milt) was observed.

Three additional surveys were flown along this coastal section on June 22, June 25 and July 21. Three herring schools were observed near Cape Denbigh on both June 22 and June 25. None were observed on July 21, but spawn (milt) was seen about 24 km south of the village of Shaktoolik.

Distribution of schools and peak aerial survey counts along this section of the study area coincided with peak commercial herring catches in this area in 1977.

Norton Bay (East of Cape Darby)

The only aerial observations of herring in Norton Bay in 1977 were made from Elim to Bald Head. Five surveys near Bald Head revealed the presence of herring on three occasions. Six schools were observed on June 15, two on June 17 and six on June 25. No herring were observed in this area on June 14 or July 21. Schools were observed up to 800 m from shore. No spawn was seen on any of the surveys.

Four medium herring schools were observed on June 25, about 50 m off the mouth of Iron Creek. One medium and three small schools were also observed about 800 m offshore near Moses Pt.

Golovin Bay (Cape Darby to Rocky Point)

Five surveys of Golovin Bay were flown from June 14 through July 21. Only 14 schools of herring were observed: three small schools on June 14

and four small and seven medium schools on June 25. Most of these schools were observed in the vicinity of Carolyn Island. However, two of the medium schools observed on June 25 were located near Cape Darby. Thus, all schools were observed on the eastern side of Golovin Bay; between Golovin and Cape Darby. All schools were within 500 m of shore. No spawn was observed.

Rocky Point to Nome

No spawning was observed in 1977 from Rocky Point to Nome. Only 18 schools of fish were seen: five small schools near Topkok on June 14 and 11 small and two medium schools scattered between Bluff and Rocky Point on June 17. These schools were oval to round in shape and within 20 m of shore. Identity of the schools was not known but could very possibly have been capelin (Mallotus villosus), herring or sand lance (Ammodytes hexapterus). A later survey of this area on August 29 revealed several small schools of fish immediately onshore. An actual count was not possible due to water conditions and the survey was thus rated unacceptable. These fish were recorded as sand lance since ground crews sampled the same area with beach seines on August 28. An estimated 45,000 sand lance were captured in a single set. Numerous other schools of sand lance were reported by the ground crew in the sampling area on that date. No herring or capelin were captured.

Aerial surveillance from Rocky Point to Nome was also conducted on July 10, July 21 and September 21 but no schools of fish or spawn was observed.

Nome to Cape Prince of Wales

A total of ten surveys were flown along the coastal waters from Nome to Cape Prince of Wales during the period June 21 through October 16. Most effort was from Nome to the Port Clarence/Grantley Harbor complex. Fish were first encountered on June 28 when five small unidentified schools were observed near the mouth of Cripple Creek about eight kilometers west of Nome. Four medium and two small schools were observed on July 10, between Cape Wooley and Cape Rodney. These six schools (unidentified) were moving toward Port Clarence between 75-100 m from shore. The following day (July 11) 23 more schools were observed from the Sinuk River to Cape Rodney. This survey was terminated at Cape Rodney due to cloud cover and wind. Thus, no survey could be made in the Port Clarence/Grantley Harbor complex but the surveyor indicated more fish were probably present.

Seventy-two unidentified fish schools (believed to be herring) were counted from Cripple Creek to Grantley Harbor on July 21. This was the peak count for this area in 1977. Forty-six of these schools were located from Cripple Creek to Point Spencer, the majority of which were within 10-75 m of the shoreline. All appeared moving northward toward Port Clarence. Three schools were inside the Port Clarence Spit within 50 m of shore. Seven schools were located inside Grantley Harbor immediately in front of Teller; five more in the upper end of Grantley Harbor at the Tuksuk Channel mouth and eleven schools ranging from small to medium

were observed within 10 m of shore from Brevig Mission to Grantley Harbor entrance.

No fish carcasses (capelin) or spawn (herring milt) was observed on any of the surveys flown from Nome to Cape Prince of Wales. Inclement weather limited the number of acceptable surveys flown in the area after the July 21 survey. Five more surveys were flown and only two more schools of fish were observed about 200 m from the mouth of the Sinuk River on August 23. Imuruk Basin surveys were all rated unacceptable in 1977 due to extremely thick phytoplankton present which obscured water visibility. It is doubtful whether or not spawn (milt) could have been seen even if it were present in Imuruk Basin. Alt (1971) also found an extremely heavy phytoplankton bloom in Imuruk Basin in July 1970.

A single small unidentified school was observed near the mouth of Lost River in 1977 along the coastline from Brevig to Cape Prince of Wales. The direction of migration could not be determined. This school was seen on July 11. Two other surveys were flown along this section of coastline on August 13 and September 9, but no fish were observed.

Cape Prince of Wales to Cape Espenberg

Nine survey attempts were made along the coastal section from Cape Prince of Wales to Cape Espenberg from July 11 through October 28. At least five of these surveys were rated as unacceptable, particularly in the fall (August through October) when smoke and inclement weather became a problem on the Seward Peninsula.

Peak counts of fish schools occurred on the first survey of July 11. Fourteen schools (11 small; three medium) were counted in the coastal waters in front of Ipek Lagoon. These schools were all 50-75 m from shore and moving toward Shishmaref. A total of 77 schools (20 small; 30 medium; 27 large) were located from Arctic Lagoon along the coast, northward, to Kividdo. About 10 of the large schools were observed in entrance channels of Shishmaref Inlet on either side of the village of Shishmaref and also at Kividdo (entrance into Cowpack Inlet). Five of the medium and one large school were observed inside Shishmaref Inlet about 20 km northeast of Shishmaref. No survey was flown on that day of Shishmaref Inlet due to its size and aircraft fuel supply.

A return survey on July 15 from Arctic Lagoon to about 30 km north of Shishmaref revealed 22 schools (10 small; eight medium; four large) present along the coastline. With the exception of two small schools seen near Shishmaref, the remainder were observed further north in the last 15-20 km surveyed.

The majority of schools observed along the coast on both July 11 and July 15 were circular to oval in shape and located at the edge of a littoral shelf. They appeared to be moving in a northerly direction 50-200 m from shore until they reached the "proper" lagoon channel. No spawn was observed and the fish were apparently heading for the inlets and lagoons present along this area of the Seward Peninsula. No schools were observed between Kividdo and Cape Espenberg apart from the large

concentration of fish present in the channel mouth to Cowpack Inlet at Kividlo. Most schools were dark green to bluish in color. Survey conditions (weather and water) were excellent. Where schools were observed in more shallow water (on the littoral shelf), they took on more irregular shapes and appeared lighter in color (brownish). These two phenomenon were apparently due to fish being more dispersed and consequently less dense in shallow water.

Coastal marine waters were sampled from Shishmaref to Kividlo from July 15 through July 17 with a rubber raft using a floating variable mesh gillnet and snag line (Figure 6). The gillnet was the same as used by ground crews sampling Norton Sound coastal waters. Total gillnet soak time for the entire three days was only 15 hours due to Chukchi Sea ice conditions. No overnight soaks were possible due to large chunks of pan ice carried by longshore currents and wind. Nets had to be constantly watched, frequently rolled and reset to avoid moving icebergs even when fished in daylight (Photographs 28 and 29). Water clarity was excellent but no fish schools could be located by boat nor by climbing shoreline bluffs for better observations.

A total of eight gillnet sets were made: one onshore, six offshore near the littoral shelf (100-200 m) and one in a lagoon channel mouth. In the single onshore, two and one-half hour set at Glass Ball Bluffs on July 15, two Arctic char, 44 Arctic flounder (Liopsetta glacialis) and four Bering cisco (Coregonus lauretta) were captured. Offshore sets amounted to nine and one-half hours and were made July 16 and 17 from Skull Flats to Cape Coke. Results were 17 Pacific herring and one starry flounder (Platichthys stellatus). The three hour set on July 17 in a lagoon channel near Rebel's Rest resulted in two Bering cisco.

The only finfish taken in all offshore sets, with the exception of one starry flounder, were Pacific herring. Only 17 were captured with most taken in the lower one-half meter of the gillnet. The net was not always fishing on the bottom since it was set near the edge of the littoral zone (where most schools were observed from the air). Consequently, it is possible that passing fish may have been deeper than the depth of the net. Of the 17 herring captured, three were taken at Reindeer Butte and 14 about five kilometers below Kividlo.

Sixteen of the 17 herring captured were sampled for age, length and sexual maturity:

11 male	Standard length range 174-190 mm. Mean standard length 183.2 mm (S.D. = 4.6 mm). Sexual maturity index II for all samples. Ten ageable samples all aged V.
5 female	Standard length range 180-197 mm. Mean standard length 187.2 mm (S.D. = 4.3 mm). Sexual maturity index II for all samples. Five ageable samples aged V.

The only success with the snag line produced two egg-bearing shrimp (sp. unkn) near Glass Ball Bluffs on July 15. One glaucous gull (Larus

hyperboreus) was obtained for stomach analysis about five kilometers southwest of Cape Coke. Contents consisted of three isopods (Mesidotea entomon) and one large shrimp (sp. unk).

As a result of the three day test fishing trip, fish schools observed on July 11 and 15 along this section of coastline were recorded as herring.

Nine small and three medium schools of fish (believed to be herring) were observed on August 6 from Ipek Lagoon to Shishmaref. The survey was aborted due to low ceilings from smoke but the surveyor believed more schools were present. Eight more schools (six small, two medium) were again observed under similar survey conditions (poor) in the same vicinity on August 20. Four other attempts were made to survey this coastal area, but all survey ratings were unacceptable and no schools were seen.

Cape Espenberg to Choris Peninsula (Eschscholtz Bay)

At least four attempts were made to survey parts of Eschscholtz Bay from July 11 through August 20. The best survey was made on July 20 when fair to excellent survey conditions prevailed. Nineteen schools (nine small; eight medium; two large) were observed within 150 meters of shore from Rex Point to the Inmachuk River. No spawn was seen but fish were believed to be herring based upon timing information gleaned from local residents at Deering. Four more schools were observed on the east side of the Choris Peninsula.

A survey was flown on August 13 in which three schools were observed near Deering in addition to one sighting of possible spawn (milt). The survey was rated as unacceptable due to smoke and weather conditions. A survey of the area on August 20 resulted in the sighting of 17 small and one medium school along the coast from Rex Point to Kugruk Lagoon. Most of these schools were located just east of Nine Mile Point. Light spawning was observed in the immediate vicinity of Cape Deceit.

Nearshore Finfish Surveys

A total of 32,458 finfish were captured in 1976 from the Yukon River Delta to Golovin Bay during the period June 9 through September 21. In 1977, 83,292 finfish were captured in the coastal waters of Norton Sound from St. Michaels to Port Clarence during the ice free period of May 30 through October 21. Combined catches for both seasons amounted to 115,750 finfish representing 38 species and 15 families (Table 8). Various cottids were also captured but were only identified to family (Cottidae) after approval from the OCSEAP project office. The 38 species identified were represented by 19 marine, 10 anadromous and nine freshwater forms (50.0, 26.3 and 23.7 percent, respectively). Species diversity by area and gear is shown in Tables 9 and 10.

The percent of marine, anadromous and freshwater species occurring in coastal marine waters in 1976 and 1977 were quite consistent from area to area (Figure 7 and Table 11). Marine species ranged from about 50-53 percent, anadromous species about 32-35 percent, and freshwater species

about 11-15 percent in all marine waters sampled. Figure 7 also shows the increase in percent occurrence of **anadromous** and freshwater species in brackish water and the decrease of marine forms.

Pacific Herring

A total of 2,352 herring were captured in 1977 throughout the study area from May 30 through October 21: 2,065 adults (88%) and 287 juveniles (12%). **Juveniles** were sexually immature, virgin fish (ages 0, 1, 11) and quite often could not be sexed. Twenty percent of the herring were captured in beach seines, 51 percent in floating **gillnets** and 29 percent in sinking gillnets.

A total of 306 herring were captured in **Golovin Bay** (Area A) of which 20 percent were juveniles (Table 12). Largest catches occurred in the Port Clarence area (Areas G, H, I): 1,750 adults (89%) and 215 juveniles (11%). Only 71 adult and 10 juvenile herring were captured in the remaining nearshore waters of the study area (Areas B, C, D, F). However, fishing effort in 1977 was limited in areas apart from Port Clarence and **Golovin Bay**. Only the Port Clarence and **Golovin Bay** areas were sampled from ice breakup to **freezeup**; the remaining coastal areas were only sampled periodically through mid summer.

Port Clarence - Grantley Harbor - Imuruk Basin: Beach seines captured 95% of all juvenile herring taken in the Port Clarence area but only 11% of the total adult herring catch. Floating **gillnets** were the most effective in catching adult herring (57%) followed by sinking **gillnets** which resulted in 32% of the adult herring catches (Tables 13 and 14). Of the juveniles captured, 59% were taken in **Imuruk Basin** with 23% and 18% taken in **Grantley Harbor** and Port Clarence, respectively. A total of 58% of the adult herring catches were in **Grantley Harbor**, with 36% in Port Clarence and only six percent in **Imuruk Basin**. Fishing effort however was lowest in **Imuruk Basin**.

No significant selection to sex by any of the gear types was found. The male to female ratios by gear types was 1:1.2, 1:0.8 and 1:1.1 for beach seines, floating **gillnets** and sinking **gillnets**, respectively. The overall sex **ratio** was 1:0.95 (Table 15).

Relative maturity of herring captured in the Port Clarence area was monitored by age class and date (Tables 16 through 18). **Sexual** maturity began mainly in the third year, also in the fourth and rarely in the fifth year. Relative maturity by sex for the entire season was also examined (Figure 8). Results show 75.8% of all **males** examined in 1977 from the Port Clarence area spawned and 71.9% of all females examined spawned. Therefore, it can be assumed that the ratio of male to female spawners approached one to one. Results on relative maturity also showed that adult herring captured in the spring were spawners **while** those in the **fall** were non-spawners (Figures 9 and 10). Most herring captured during the spring and summer were post spawning fish (Figure 11) indicating at least some spawning occurred prior to the start of sampling. Juvenile herring were not captured in significant numbers until mid-August although they were captured in the spring during **ice** breakup.

A total of 1,068 herring were sexed and measured (standard length) throughout the sampling season. The overall mean length for males and females combined was 185.5 mm, having a standard deviation of 24.4 mm (Figure 12). Mean length at age was calculated on 834 herring (Figures 13 and 14; Table 45).

In addition to the 834 herring which were compared for mean length and age, 78 more juveniles were captured during the season but no **scales** were available for age analysis. Nineteen juveniles were captured on June 29 in Grantley Harbor. The mean standard length for these herring was 88.0 mm with a standard deviation of 9.96 mm. It is not known whether these herring were Age 0 or Age I. Fifty-seven juvenile herring were captured at several stations throughout the Port Clarence area from August 22-30. Their mean length was 40.9 mm (standard deviation equals 13.1 mm). It is safe to assume that these 57 fish were young of the year (Age class 0) since the Age 0 herring in Table 45 have a mean length of 90.5 mm and they were all captured from September 29 through October 8 (approximately 30 to 35 days later). This represents a daily growth rate of about 1.4 to 1.7 mm or 3.5-4.0% in this area for Age Class 0 herring. Two other juveniles were captured in Imuruk Basin; one on July 10 (length 89 mm) and the other October 4 (length 99 mm).

One hundred and three herring ranging from 0-14 years of age were sampled in October for fork and standard length comparisons by sex. Results were plotted and linear regressions calculated for each sex (Figure 15):

Sex	n	Slope (a)	Intercept (b)	r	r ²
male	37	1.08158	2.14568	0.99507	0.99016
female	56	1.08548	0.91009	0.99576	0.99153
juvenile	10	1.08121	2.35171	0.99703	0.99407
combined	103	1.07922	2.33062	0.99839	0.99678

A change in age composition occurred from spring (breakup) to fall (freezeup) in the Port Clarence area in 1977 (Figures 16 through 19). Both juvenile and adult herring were present in the spring with the oldest ageable herring being 15 years. Spring spawning herring were dominated by Age Class V (75.6%). As the season progressed into the summer and fall, Age Class V herring were still abundant but Age Class III herring dominated the percent age composition. Age Class V was again dominant by freezeup followed closely by Age Class III. The highest percentage of ageable juvenile herring were Age Class 0 followed by Age Class I and Age Class II. Herring as old as 14 years were present throughout the entire sampling season. Fifty-six percent of the herring captured in Imuruk Basin were juveniles (Age Class 0, I, II), while only six and five percent of herring captured in Port Clarence and Grantley Harbor, respectively, were juveniles. These figures include both aged and non-aged juveniles.

Golovin Bay: Beach seines captured 100% of the catch of juveniles and less than one percent of the catch of adult herring in Golovin Bay in 1977. With the exception of two Age II herring captured in early July identified as spawners, all juveniles (sexually immature fish) were taken in early September at a single station in Golovin Bay. This location was at Carolyn Island on the east side of Golovin Bay. Floating gillnets captured 79% of all adult herring; sinking gillnets caught 21% (beach seines caught only one adult herring). There was no apparent selection by sex of different gear types and the overall male to female ratio was 1.00:0.61 (Table 19).

Relative maturity of herring captured in Golovin Bay was monitored by age class and date. Sample size of juvenile herring was too small to determine when sexual maturity begins but some evidence suggested it occurs in the third and fourth year. Results on relative maturity show that herring captured in the spring were spawners while those in the fall were non-spawners (Figure 20).

A total of 228 herring were sexed and measured (standard length) throughout the sampling season. The overall mean length for males and females combined was 212.8 mm with a standard deviation of 28.3 mm (Figure 21). Mean length at age was calculated on 229 herring (Figures 22 and 23; Table 45).

One hundred fourteen herring ranging from 1-9 years of age were sampled in October for fork and standard length comparisons by sex. Results were plotted and linear regressions calculated for each sex (Figure 24):

Sex	n	Slope (a)	Intercept (b)	r	r ²
male	69	1.04224	6.21020	0.99546	0.99094
female	45	1.02564	9.89105	0.99580	0.99162
combined	114	1.03596	7.59044	0.99561	0.99124

There was little change in the percent age composition of spring spawning herring and non-spawning fall herring. Herring of Age Class III were dominant followed by Age Class V (Figure 25). Herring of older ages were present in both the spring (up to Age Class X) and fall (up to Age Class IX) samples.

Stomach Analysis: Most of the 146 herring stomachs examined (75%) from the spring of 1976 at IMS were either empty or contained only traces of food items. Only 25% of those stomachs examined were at least 25% or more full of which only 3.4% were 100% full (Table 20). The frequency of occurrence and percent number of food items found per stomach are shown in Table 21 and Figure 26.

Juvenile Salmon

In 1977 good sampling coverage was made in the Golovin Bay area (Area A) with limited coverage along the southern and eastern coastline of Norton Sound (Areas B, C, D). However all four areas, unlike 1976, received coverage during a two week period immediately following ice breakup. The best coverage in 1977 was in Area A.

A total of 4,584 and 1,717 juvenile pink and chum salmon, respectively, were captured in beach seines in Golovin Bay from June 9 (ice breakup) until July 9. Catches of both species peaked from June 20 through June 26. The last juvenile pink salmon was captured in Golovin Lagoon on July 7 while the last juvenile chum salmon in the nearshore waters of Area A was captured in outer Golovin Bay on July 9.

Fork lengths of 329 and 360 juvenile pink and chum salmon, respectively, indicated that juvenile chum salmon average about 4.2 mm larger than juvenile pink salmon (Table 22 and Figure 27). Overall mean fork lengths were 38 mm and 42 mm for pink and chum salmon, respectively. Juvenile pink salmon increased from about 32 mm in the second week of June to about 54 mm by the first week in July (Table 23). This increase in growth (22 mm) over 28 days indicates a daily growth rate of 0.79 mm. Juvenile chum salmon for the same period increased from about 35 mm to about 59 mm, resulting in a daily growth rate of about 0.86 mm. Growth curves are shown for each species in Figures 28 and 29.

The only other area where juvenile salmon were captured in any numbers was between Bluff and Rocky Point (Area F). A total of 75 juvenile pink salmon and 14 juvenile chum salmon were captured during Period 1 on June 27 and 28. The mean fork lengths of the juvenile pink salmon were 44.5 mm and 52.0 mm on June 27 and 28, respectively. No measurements were taken on the chum salmon. Ninety additional juvenile pink salmon were captured in this area during Period 2 but no lengths were taken.

Only 11 juvenile chum salmon and no juvenile pink salmon were captured throughout the remainder of the study area in 1977. Seven of the chum salmon were caught in Area C, one in Grantley Harbor and one in Imuruk Basin. The only other juvenile salmon captured in 1977 consisted of 12 cohos taken in Golovin Bay during Periods 1-3.

Larval Fish Catches

A total of 5,402 larval fish were captured incidentally in beach seines throughout the nearshore waters of the study area in 1977. Three families were represented: 1) **Osmeridae**, 2) **Gadidae** and 3) **Cottidae** (Table 24). Two species of **Osmerids** were identified: boreal smelt and pond smelt. These catches were not included when calculating catch per unit efforts since they were considered too small to be effectively captured by sampling gear. However, **Osmerids** were by far the most abundant and frequently encountered larval fish. Larval boreal smelt were encountered in all areas while larval pond smelt were only encountered in Imuruk Basin (Area I).

Other Finfish Catches

Combined gillnet and beach seine effort in coastal marine waters from St. Michaels to Port Clarence resulted in a total finfish catch of 83,123 from May 30 through October 21, 1977 (Table 25). Included in this catch were 5,402 larval fish taken with beach seines. An additional 169 finfish were captured in beach seines in the lower part of Fish River and the Unalakleet River lagoon. Excluding these latter areas (E and URL), 155 beach seine sets were made in marine waters. Only two sets did not produce catches. These two sets were in the Port Clarence/Grantley Harbor area. The remaining 153 sets resulted in 73,326 finfish (excluding larval fish catches).

The highest beach seine CPUE (6,302) occurred in the area from Rocky Point to Bluff (Area F) (Figure 30), reflecting the high abundance of sand lance along this section of Norton Sound. The lowest beach seine CPUE's were in southern Norton Sound from Egavik to Cape Stebbins, being less than 40 fish per set. Beach seine CPUE's from Egavik to Cape Denbigh, in Golovin Bay and in the Port Clarence/Grantley Harbor area ranged from 131-239 fish per set. Higher catches were experienced in Imuruk Basin; 444 fish per set.

Excluding the Unalakleet River lagoon and Fish River sampling effort, 509.4 gillnet hours were fished in 1977. Thirty-eight percent (193.6 hours) of this effort was made with sinking gillnets (offshore sets) while 62% (315.8 hours) was with floating gillnets (onshore sets) (Table 25). The average duration of offshore and onshore sets was 1.3 and 1.4 hours, respectively. Negative catches occurred in 26.1% (50.6 hours) of the offshore sets while only 9.8% (30.8 hours) of the onshore sets resulted in no catch.

Offshore sinking sets throughout the study area always caught the fewest species and numbers of fish in both 1976 (Barton 1977) and 1977. Onshore floating sets were more closely, if not equal to beach seines in the number of species captured. The average water depths for sample areas where offshore sets were made with sinking gillnets were:

South and eastern Norton Sound (Areas B,C,D)	4.4 m
Golovin Bay to Bluff (Areas A,F)	5.7 m
Port Clarence area (Area H)	3.6 m
Grantley Harbor area (Area G)	3.4 m
Imuruk Basin area (Area I)	3.1 m
Mean depth for entire study area	4.4 m

It is difficult to say in which area certain species or fish were most abundant in 1977 since all areas did not receive equal coverage during each two week sampling period. Species abundance varies by area with time as shown by CPUE values (Table 26). Among the most abundant species captured in 1977 were sand lance, pond smelt Hypomesus olidus, juvenile pink and chum salmon, saffron cod (Eligenus gracilis), starry flounder and Pacific herring.

The three most frequently encountered species in 1977 captured in beach seines for the entire season and all areas combined were starry flounder (43%), saffron cod (41%) and pond smelt (37%). The three most frequently occurring in **gillnets** were saffron cod (33%), starry flounder (30%) and Pacific herring adults (27%). Percent frequency of occurrence for gear types combined was saffron cod (36%), starry flounder (34%), Pacific herring (19%) and pond smelt (11%). Again, the percent frequency of occurrence among species also changed with time and by area just as species abundance (Table 27).

Southern and Eastern Norton Sound: A total of 25 stations were fished from **Cape Stebbins** to Cape **Denbigh** (areas B, C, D) in 1977 (Figure 3). Only eleven of the 25 stations **could** be beach seined in addition to fishing **gillnets**. Consequently, beach seine effort was minimal along this area of Norton Sound.

The first sampling round was conducted during the first two weeks following ice breakup from May 30 through June 20 (Period 1), with a second round of sampling conducted from July 16 through August 10 (Periods 4 and 5). A total of 17 seine sets and 99.9 **gillnet** hours were fished during these periods. The CPUE was 91.4 fish. Beach seines and floating **gillnets** captured 19 different species of fish while sinking sets only captured eight species. Sand lance was the only species captured in 1977 which was not found in these areas in 1976. All were captured in Period 4 in two seine sets; 600 at **Wagonbox** Creek near **Golsovia** and 135 at the mouth of Junction Creek between **Egavik** and Beeson Slough.

Four juvenile herring (3 years of age) were among the nine fish caught in sinking **gillnets** in area B during the entire sampling season. They were captured in Period 4 on the south side of Cape **Denbigh**. Six more juvenile herring were also captured in Period 4 with beach seines and were taken near the mouth of **Wagonbox** Creek in area D.

The only juvenile salmon captured were caught during Period 1 in area B. Twelve pink and seven chum salmon juveniles were all captured on the north side of **Tolstoi** Point. No other juvenile salmon were captured in any of these three areas in 1977.

The most abundant species captured with beach seines in area C was saffron cod while sand lance were the most abundant in seine catches in areas B and D. Arctic char, starry flounder and Pacific herring adults were among the most abundant species taken with **gillnets** in all areas. **Ciscos** were also abundant. **Least cisco, boreal smelt (*Osmerus eperlanus*)** and starry flounder were among the most frequently encountered species in these three areas.

W : Sampling in **Golovin** Bay from Cape Darby to Rocky Point Area A began June 9 (breakup) and was conducted through July 20 (Periods 1-3) (Figure 3). Further sampling was conducted from August 19 through October 21 (Periods 6-9). A total of 14,928 fish were captured in 68 beach seine sets. Forty-four sinking **gillnet** sets captured 230 fish during 69.9 hours of fishing time. Floating **gillnets** fished for 182.7 hours resulting in 879 fish. The CPUE for sinking and floating **gillnets**

was 3.3 and 4.8, respectively, for the entire sampling season. The beach seine CPUE was 219.5 fish. Fourteen species were represented in the sinking **gillnet** catches, 17 in floating **gillnet** and 22 in beach seine catches.

Abundance of fish, based upon CPUE indices, varied by species with time (Table 28). For example, juvenile salmon were only present in significant numbers during Periods 1 and 2 and were not found anytime after Period 3. Sand lance were present in large numbers beginning in Period 3 and remained significantly abundant through Period 7; very few were captured in the early spring or fall in **Golovin Bay**. **Gillnet** catches of herring were only made during Periods 1, 7 and 8 in 1977, although beach seines caught herring in all periods fished.

The most abundant species captured with beach seines in **Golovin Bay** in 1977 were sand lance and pink and chum salmon juveniles. Pacific herring, saffron cod and starry flounder were the three most abundant species captured in **gillnets** in 1977. Among the most frequently encountered species taken in **gillnets** were saffron cod, Pacific herring, starry flounder and humpback whitefish. Saffron cod, starry flounder and ninespine sticklebacks were the three most frequently encountered species in beach seine.

Port Clarence Area: Selected stations were periodically fished in the Port Clarence area (areas G, H, I) from June 27 through October 12, 1977 (Figure 3). **Gillnets** were fished 137.3 hours of which 48%, 38% and 14% of the effort was in Port Clarence, **Grantley Harbor** and **Imuruk Basin**, respectively. The highest **gillnet** CPUE occurred in **Grantley Harbor** and the lowest in **Imuruk Basin**. Adult Pacific herring were the most abundant species captured with this gear type in both **Grantley Harbor** and **Imuruk Basin** and the third most abundant in Port Clarence. This species was also the most frequently encountered with **gillnets** in all three areas. Other abundant species captured with **gillnets** in these areas were saffron cod, Bering **cisco**, starry flounder and boreal smelt.

The highest beach seine CPUE occurred in **Imuruk Basin** followed by **Grantley Harbor** and Port Clarence, respectively. Pond smelt, sand lance and saffron cod were the three most abundant species captured with beach seines in **Grantley Harbor** and Port Clarence, while pond smelt, ninespine sticklebacks (*Pungitius pungitius*), least **cisco** and juvenile Pacific herring were the most abundant as well as frequently occurring species in **Imuruk Basin**. Saffron cod, pond smelt, sand lance, juvenile Pacific herring and least **cisco** were the most frequently occurring species in **Grantley Harbor** and Port Clarence. Abundance and frequency of occurrence of species varied from area to area with time.

Length Frequencies: A total of 12,000 length measurements were obtained from species other than herring. An examination of the ranges and means sampled by gear type (Tables 29 through 32 and Figures 31 through 41) shows that larger and/or older fish were sampled with **gillnets**, whereas beach seines were more selective for smaller and/or younger fish. Except in the southern and eastern portion of Norton Sound (Areas B, C, D) beach seines always captured more species than **gillnets** (Figure 42). They also captured larger numbers of fish (in all areas) than **gillnets**.

This is probably due to the affinity of small and young fish to school in large numbers.

Physical and Chemical Data

Surface water temperatures revealed the southern coastal section of Norton Sound to be much cooler than in other areas examined during the first two weeks following ice breakup in early June (Table 33). This was the last area in eastern Norton Sound to become ice free (Photographs 1 through 3). Water temperatures in the **Golovin** Bay and Port Clarence areas were much warmer for the same period of time, probably owing to the influx of relatively warm river water in these areas.

Surface salinities were monitored along eastern Norton Sound coastal areas in 1976. The lowest salinities occurred in June and progressively increased into the fall (Table 34). This is probably a function of melting pack ice and freshwater runoff throughout the season from many of the river systems in Norton Sound as well as Yukon River discharge.

Stomach Analysis

A detailed discussion of results on the stomach analysis of 23 species of finfish collected from eastern Norton Sound in 1976 can be found in **Neimark et al.** (1978). Opossum shrimps (**Neomysis spp**) were found to be the most important food source. This genera was the most frequently occurring prey and occupied the largest percentage by volume of stomach contents. Unidentified eggs and the copepods, **Acartis clausi** and **Eurytemora spp.** were the most abundant food item in stomach contents.

It was found that most predators appeared to be opportunistic feeders, although boreal smelt and saffron cod, the most frequently captured fish species, were generalists, i.e., they consumed all food groups. **Eighty-five** different taxa of prey were identified. Larval boreal smelt were among the most important prey consumed. This taxon occurred in 30% of the 23 fish species examined.

Offshore Finfish Surveys

The Royal Atlantic fished preselected townet and **gillnet** stations in the offshore waters of Norton Sound from June 22 through July 12. An attempt was made to enter the **Chukchi** Sea on **July 8** to begin sampling in Kotzebue Sound. However, severe pack ice conditions necessitated return to Norton Sound. An aerial survey along the Seward Peninsula was flown on July 11 to examine ice conditions in Bering Strait and the **Chukchi** Sea (Photographs 6 and 28). The large vessel charter was terminated on July **12** due to main pack ice and drifting pan ice conditions which precluded entry into the Kotzebue Sound study area at Cape Espenberg.

Gillnetting Studies

A total of 22 offshore **gillnet** sets were made in Norton Sound resulting in 232.9 hours of total soak time. Sets ranged from 4.2 to 23.0 hours in duration with an average of 10.6 hours per set. Seven stations were

fished with stationary gear while 15 sets were made by drifting with the gillnets. Distance drifted ranged from about two to forty kilometers with an average drift of ten kilometers for the 15 drift sets. Two of the 22 sets made (23%) resulted in no catch.

Surface water temperatures at the 22 gillnet stations ranged from 3-15 Co with an average temperature of **9.9°C**. Depth of stations sampled ranged from 5-36 m with a mean of 15.7 m.

Eight species were represented in a total catch of 345 fish:

<u>Species</u>	<u>Catch</u>	<u>Percent</u>
Pacific herring	315	91
Arctic char	11	3
Starry flounder	8	2
Bering Cisco	5	1
Chum salmon	2	1
Coho salmon	2	1
Pink salmon	1	TR
Cottid	<u>1</u>	<u>IR</u>
Total	345	100

Ninety-one percent of the total catch was Pacific herring of which 82% were captured in only two of the 22 stations sampled (Stations 1 and 20) (Table 35). Consequently, data was grouped as follows for analysis of herring results: station 1; stations 2-19; stations 20-21; and, station 22 (Table 36). All herring catches in offshore waters occurred in Norton Sound (east of 166° W. longitude) with the exception of a single specimen captured on July 2 inside Port Clarence.

Spawning herring were taken only in June at stations 1-6 (Table 37). Post spawners were captured from July 9 through July 12 at **stations** 19, 20 and 22. Sexually immature herring (gonad index II) were present at all stations where herring were captured in significant numbers. These were predominantly Age Class III-V herring (Table 38). Relative maturity by age **class** is shown in Figure 43.

Herring catches were examined by panel mesh size and results revealed 20% were captured in 38mm, 68% in 51 mm and 12% in 64 mm **mesh** (Table 39). Various mesh sizes were selective on herring age classes (fish size) (Figure 44). Age Classes IV and V dominated catches from 38 mm **mesh** nets; Age Classes V - VIII dominated in 51 mm mesh nets; and, Age Classes VIII and IX were dominant in 64 mm mesh catches.

Mean length and weight-at-age were plotted for the total herring catch in 1977 (Figure 45). Percent age composition of herring captured on June 22 at station 1 were dominated by Age Classes VII and VIII, while those taken on July 10 at station 20 were predominantly Age Class V (Figure 46). Overall length frequency distribution is shown in Figure 47.

Lengths and weights of other species captured were:

1. Fork lengths for eleven Arctic char ranged from 149-485 mm with a mean of 292 mm (**SD=118.3**). Weight ranged from 21-1,175 gms with a mean of 350 gms (**SD=329.1**).

2. Five boreal smelt captured ranged in length from 169-360 mm with a mean of 241 mm (SD=93.1). Range in weight was from 58-367 gms with a mean of 169 gms (SD=155.1).
3. Eight starry flounder ranged in length from 259-425 mm with a mean of 363 mm (SD=53.6). Range in weight was from 167-1,000 gms with a mean of 627 gms (SD=254.7).
4. Two adult male chum salmon had weights and lengths (mid-eye to fork of tail) of 3.4 and 3.8 kgs, and 575 and 603 mm, respectively. An adult coho salmon female measured 580 mm with a weight of 4.0 kgs. A juvenile coho salmon measured 162 mm (44 gins) while a single adult male pink salmon measured 455 mm and weighed 1.45 kgs.

Townetting Studies

A total of 83 thirty minute tows were made in Norton Sound from June 22 through July 13, 1977. Depth of towing stations ranged from four to 36 meters with an average of 14.7 m. Surface water temperatures among stations ranged from -1° to +15°C. with a mean of 9.2°C.

Species captured and frequency of occurrence of each are shown in Table 40. Larval fish were the most frequently encountered (66%) but were considered as incidental catches due to their small size. Larval fish catches consisted of: Cottidae; Gadidae (Eleginus gracilis); Stichaeidae (Lumpenus sp.); Agonidae (Sarritor frenatus); Liparidae (Liparis sp.); Osmeridae (Malloetus villosus); and Ammodytidae (Ammodytes hexapterus).

Larval fish were encountered throughout the entire sampling period. Figure 48 shows the general distribution of larval fish catches as well as stations or areas (in the case of gadids and sand lance) where distribution of these species was documented. Catches from many stations were mixed when submitted for identification and the station of occurrence for a particular species could not be determined. Consequently distribution, apart from where larval fish in general were captured, is not completely accurate. For example, gadids may have also been present in other areas denoted as larval fish in addition to areas designated as gadid occurrence. The only completely accurate distribution information concerns crab larval. All larval crabs (species unknown) were taken in the vicinity of Port Clarence.

Five fish species were captured in addition to larval fish during the sampling period: Ninespine sticklebacks, starry flounder, Bering wolffish (Anarhichas orientalis), saffron cod and pink salmon. Forty-five ninespine sticklebacks were taken at eight stations. Forty-two were measured and ranged from 37-56 mm. The mean length was 49 mm. Eleven starry flounder were captured at five stations and their mean length and weight were 309 mm and 355 gins, respectively. Lengths and weights ranged from 242-387 mm and 152-825 gins, respectively.

Three juvenile **wolffish** were captured at three stations and had lengths of 42, 42 and 50 mm. A single juvenile saffron cod was captured. Its length was 92 mm and weight **three** grams. A single juvenile pink **salmon** was captured off Cape Nome on June 23 and measured 31 mm (0.7 gins).

Anuk River

Hand purse seining for **salmon** smelt in the Yukon River was conducted for 23 days at eight stations during the period June 7 through July 7. A depth profile of **the** sampling area was developed (Figure 49). The deepest part of the river was 16.2 meters on the cut bank side near the mouth of the Anuk River. The Yukon River water current was estimated at 2.1 m/sec at the **sample** location.

A total of 1,915 **finfish** were captured during the **sample** period of which five were lamprey (Table 41). The most abundant catches were juvenile whitefish species (Figure 50). Distinction between juvenile broad and humpback whitefish could not be made. Juvenile **burbot** and chum salmon smelt, respectively, were the next most abundant species captured.

Catch per unit effort (number of fish per seine set) was calculated for each species to examine spatial and temporal distribution during the sampling period (Figures 52 through 58). Although there was no apparent affinity of any species to migrate down a particular section of the river, distinct differences in timing by species occurred (Table 42). Peak catches of **chum salmon** smelt occurred on June 13 and 15. No salmon smelt were captured in significant numbers after June 24. A downstream migration of juvenile whitefish, juvenile **burbot** and juvenile **sheefish** was documented, occurring during the first week of July.

Fork lengths were collected on 265 chum salmon smelt throughout the **sample** period (Figure 59 and Table 43). Lengths ranged from 31-58 mm, with a mean of 41 mm and standard deviation of 7.5 mm. Ninety-two juvenile **sheefish** fork length measurements ranged from 35-74 mm with a mean of 56 mm (Figure 60). Juvenile whitefish were **also** sampled for fork length. Eighty-nine ranged from 20-51 mm with a mean and standard deviation of 34 mm and 7.1 mm, respectively (Figure 61). An additional 468 measurements **fell** between 20 and 45 mm, but no mean was calculated. Thirty-five juvenile **burbot** ranged from 18-32 mm, with a mean and standard deviation of 23 mm and 3.4 mm, respectively. An additional 88 ranged from 19-25 mm. A **single burbot** specimen measured 105 mm (Table 43).

Daily water level fluctuations in the Anuk River (Figure 62) and surface water temperatures (Figure 63) in the Yukon River were monitored at noon from June 6 through July 7. Peak chum salmon smelt catches occurred when water temperatures ranged between 9°-11°C. Peak catches of other juvenile fish occurred when water temperatures were 14°-14.5°C during the first week of July.

DISCUSSION

Subsistence Utilization Surveys

Species utilized for subsistence differs somewhat by village throughout the study area (Table 44). A similarity does exist among villages in that about seven families of fish are used by almost all villages to some degree. These include: *Clupeidae*, *Osmeridae*, *Gadidae*, *Pleuronectidae*, *Salmonidae*, *Coregonidae*, and *Thymallidae*. Species Utilization depends to a great extent upon seasonal availability. Herring for example are captured in the spring when spawning runs occur in the southern and eastern portion of Norton Sound. Villagers residing on the Seward Peninsula, however, take herring both from spring spawning runs and also in the fall when herring appear in nearshore waters, at for example, Golovin, Teller and Shishmaref. Another species which is taken on an opportunistic basis is capelin which apparently spawn along the beaches of Nome in some years.

Saffron cod are utilized in all villages but subsistence effort is primarily limited to the fall and winter months. Its use is supplemented by other fishery resources during the spring and summer although this species is present year round in all areas according to survey information.

It was not possible to accurately quantify the amount of herring or other fishery resources harvested for subsistence purposes during the course of these investigations for two major reasons: 1) absence of village fishermen at the time of subsistence surveys; and, 2) the absence of subsistence caught fish on many occasions for identification by OCS personnel. Information obtained from personal interviews often resulted in a local name (underlined in Table 44) given for a fish species taken for subsistence use. The authenticity of species harvested could not be verified by the surveyor since fish were often unavailable. These problems also occurred in studies conducted south of the Yukon River Delta in 1976 (Barton et al. 1977). However, they seemed more pronounced north of the Yukon River. Typical examples include capelin being called "hooligan" in the Nelson Island area and "cigarfish" in Nome; pond smelt are also called "cigarfish" by some residents of Nome and other areas of Norton Sound; ciscos are referred to as "herring" in some areas of Kotzebue Sound and are called "whitfish" by Shishmaref residents.

A third factor which hindered accurate catch quantification was differences found in units of catch reporting. Residents would record subsistence catches in numbers, strings, sacks, buckets, tubs or pounds of fish.

Herring

Most subsistence fishing for herring within the study area centered on spring spawning runs, although a number of residents from Golovin northward to Kotzebue also harvested herring from non-spawning fall runs to a limited extent. Limited winter catches are also made while jigging for cod through the ice from Port Clarence northward. Consequently, the duration of herring subsistence fishing normally lasts for only a short period each year. Effort generally commences immediately following ice breakup of the Bering and Chukchi Seas from late May to early July with

intense fishing usually lasting not longer than two to three weeks. An exception to this is the limited fall herring harvests made on the Seward Peninsula.

Most subsistence caught herring are intended for human consumption. They are generally **woven** into grass strings or draped over wooden racks and allowed to sun-dry for several days. Late **fall** and winter herring are often eaten raw after freezing and slicing into small pieces. Some are fed to dogs, especially in those villages where dog teams are more common. Herring spawn on **rockweed** kelp is also harvested but on a small scale. Its use is primarily confined to southern and eastern Norton Sound.

Herring are usually caught with set **gillnets** with mesh sizes of 57-64 mm although some are beach seined. **Gillnets** are either purchased or salvaged Japanese nets found washed ashore.

Herring use as a subsistence item throughout the study area is influenced by timing and abundance of herring spawners, occurrence of other fishery resources, occurrence of marine mammals and large game animals, commercial salmon fishing and other employment opportunities, such as firefighting, and the number of dog teams per village. These factors no doubt influence the extent of use of other fishery resources as well.

Survey results from 1976 indicated that herring were more important as a subsistence item in Norton Sound than in **Kotzebue** Sound. In general, subsistence use by village decreases in a northerly direction with greatest herring harvests occurring in southern Norton Sound. Utilization at Point Hope was not documented. **Stebbins** and St. **Michaels** residents utilized herring in 1976 more than other residents throughout the study area. Commercial salmon fishing is restricted in this area.

Residents of **Unalakleet**, **Shaktoolik**, Moses Pt., and Elim also utilized herring, but most effort was devoted toward commercial salmon fishing, thereby, limiting the effort on herring. Subsistence fishing for herring by villagers along the Seward Peninsula was quite limited in 1976. This was attributed to the lack of dog teams and occurrence of other fishery resources available for harvest such as smelt, whitefish and **sheefish**. OCS ground crews in 1977, had difficulty in finding local residents in **Teller** who wanted excess herring captured for samples from the spring spawning run in late June and early July. Subsistence effort in 1976 and 1977 in Kotzebue Sound appeared to be centered around the harvest of marine mammals and large game animals.

Most Norton Sound residents indicated that herring subsistence utilization has decreased from previous years for three major reasons: 1) lack of dog teams, many of which have been replaced with **snowmachines**; 2) employment opportunities, and 3) fewer numbers of herring. Many also feel that foreign fishing effort has reduced herring abundance from previous years. This view was also shared by coastal residents on the west coast residing below the Yukon River Delta (Barton et al. 1977).

It should be realized, however, that the major gear for subsistence herring fishing throughout the study area is set **gillnets** having a

particular mesh size (generally 57 to 64 mm). Results from the Royal Atlantic cruise in 1977 indicate that these mesh sizes select older age classes (larger) of herring. Barton et al. (1977) also found a similar situation for gill net caught subsistence herring near Cape Romanzof in 1975. Therefore, in years when the age composition of herring is predominantly III-V, smaller subsistence catches may be experienced than when the predominant age class composition is VI-IX. This is one factor which should be considered when examining catch trends.

It is apparent that herring are more important as a subsistence item to residents below the Yukon River Delta than to those residents in Norton Sound and Kotzebue Sound. This difference in herring subsistence utilization may possibly be explained by: 1) The availability of alternate food sources, e.g., marine and large terrestrial mammals; 2) a lower abundance of herring; and, 3) employment opportunities north of the Yukon River.

Clupeidae (Herring)

Timing and Distribution

Appearance of herring on spawning grounds appears to be greatly influenced by climatological conditions particularly the extent and distribution of the Bering Sea ice pack. Results reveal that herring spawn throughout most of Norton Sound during the spring and early summer (late May through June). Spawning occurs slightly later in the Port Clarence area (late June through early July) and mid to late July along the northern portions of the Seward Peninsula. Some evidence found in 1977 suggests that spawning may occur as late as August in parts of Kotzebue Sound.

The first record of herring spawning was reported in St. Michaels Bay in mid June in 1976 and 1977. Spawning has been recorded as early as May 30 in this area (ADF&G files), being greatly dependent upon ice breakup conditions. Zagoskih (1956, not seen by author; cited by Rumyanstev and Darda 1970) reported, during his travels on the southern coast of Norton Sound, that herring arrived annually in the Sound at the end of April, passing under the ice. Rumyanstev and Darda (1970) therefore made the assumption that spawning did not begin before the second half of May (taking into account the difference between the Gregorian and Julian calendars). Alaska Department of Fish and Game files indicate that peak spawning in Norton Sound usually occurs from June 1-14.

Two pulses of spawning were documented at Cape Denbigh in 1976. Spawn was observed on June 20 and on June 30 on the south side of the Cape. The peak aerial survey count in 1977 of this area occurred on June 17, which coincided with peak commercial herring catches at Cape Denbigh in that year. A total of 20,896 pounds of herring were captured with beach seines and gill nets from June 15 through June 20 by commercial fishermen. The average roe recovery rate of 6.5%. Tests made prior to commercial operations by the processor revealed a 9.0% roe recovery, but the percentage decreased once production began. A few herring were taken commercially with gillnets at Tolstoi Point on June 24 but roe recovery was poor (3.5%).

Tests conducted by a commercial herring buyer revealed a 14.3% roe recovery from a sample of herring captured in **Golovin** Bay in late May 1976. The OCS sampling program began in **Golovin** Bay on **July 3**, 1976, and few herring were captured. No information was gleaned on spawn timing in that year. Spawning was documented in **Golovin** Bay in 1977 at Carolyn Island during the last week of June as OCS crews encountered herring with a relative maturity index of 6. The largest percentage of these herring were captured from June 22 through **July 6** (79.6%). A total of 27.3% of herring sampled from July 7-21 were spawners and no evidence of spawning was documented after that date in 1977 in **Golovin** Bay.

The Port Clarence area was sampled only in 1977. Sampling commenced with ice breakup on June 27, and until July 6, only 4.7% of the herring sampled were spawners (maturity index 6), while 44% of those collected were post spawners (maturity indices 7 and 8). Young-of-the-year herring were also present during this period, although not in significant numbers. These data indicate that some spawning occurred prior to ice breakup in the Port Clarence area in 1977. From July 7-21 only 3.6% of the samples collected were spawners while 84.7% were post spawners. Therefore, it can be concluded that spawning commenced in the Port Clarence area in 1977 prior to late June and continued through mid-July with peak spawning apparently occurring sometime in the early part of July. Peak aerial survey counts of fish schools in the Port **Clarence/Grantley** Harbor area in both 1976 and 1977 occurred on July 21.

Herring arrived along the northwestern coast of the Seward Peninsula in about mid-July in 1977. These herring were believed destined for the lagoon areas which connect and comprise **Shishmaref** and Cowpack Inlets, since no fish schools were observed further north than **Kivido** in either 1976 or 1977; the last entrance along this coastal section to the lagoon system. Peak aerial survey counts in 1977 occurred on July 11 in these areas. Limited samples collected from July **15-17** revealed sexually immature, Age V herring present. No spawners or post spawners were captured. Consequently, it is assumed that spawning occurred later than mid-July in this area in 1977. Aerial survey observations along this section of coastline indicated that the herring were moving into the lagoon areas from a southerly direction.

Peak herring survey counts along the northern coastline of the Seward Peninsula and southern Kotzebue Sound (**Eschscholtz** Bay) occurred on July 20 and August 20, 1977. Possible herring spawn was observed on August 13 at Cape Deceit and again on August 20 at Nine Mile Point. Weather conditions precluded a positive verification on both surveys.

In general, it can be said that most herring spawning populations appear near the western Alaska coast immediately after ice breakup in mid-May and early June (Figure 64). Spawning progresses in a northerly direction along the coastline beginning in mid to late May in Bristol Bay (Barton et al. 1977) and continues until **late July** and **August** along portions of the Seward Peninsula and the Chukchi Sea. Both **pre** and **post** spawning segments of herring populations remain in the nearshore waters throughout the early spring and summer months.

Relatively small fall runs of herring are known to occur in Golovin Bay, Port Clarence, along the west coast of the Seward Peninsula and in Kotzebue Sound. Samples collected from Golovin Bay and Port Clarence in 1977 revealed that the reproduction organs were relatively undeveloped and that these herring do not spawn in the fall (September and October). A similar finding was made from samples collected in Golovin Bay in mid-October, 1963 (ADF&G files). Herring of this run are of prime quality with firm flesh and a high oil content. It was these fall herring runs which supported earlier commercial herring operations in Norton Sound from 1916-1941. Fall herring were apparently also present in former years in other areas of Norton Sound according to local residents.

Herring are widely distributed throughout the coastal and offshore waters of Norton Sound and Kotzebue Sound in the fall and early winter months. This is not only evident from local resident interviews, but also from demersal trawl catches of herring in September and October (Wolotira et al. 1977). Both mature prespawning and sexually immature herring were captured in offshore waters during this period. These herring may or may not have been segments of the fall herring runs which occur in the nearshore waters along the Seward Peninsula in September and October.

Herring are captured in several areas under the ice throughout the winter months. Most of these fish are taken by local subsistence fishermen while jigging for cod. These areas include Golovin Bay and Safety Sound in Norton Sound, Imuruk Basin in Port Clarence, Shishmaref and Cowpack Inlets along the northwest coast of the Seward Peninsula and Kugruk and Kiwalik Lagoons in southern Kotzebue Sound. Herring were captured in mid-October in Cowpack Inlet in 1977 and in Shishmaref Inlet in March 1978. These samples were positively identified by ADF&G biologists. Herring were found in the stomachs of sheefish captured in Hotham Inlet on November 23, 1963 (ADF&G files).

Other evidence of the presence of herring in nearshore waters throughout the winter months include the occurrence of this species in seal stomachs. Herring occurred in one of 27 ringed seals (*Phoca hispida*) collected at Nome from March 9-18, 1977. Herring occurred in 11 of 14 spotted seals (*P. largha*) collected at Shishmaref from October 14-24, 1977 and in 13 of 30 ringed seals collected January 6 through February 2, 1978. Marine mammal biologists who analyzed the stomachs indicated that there was no doubt these herring were ingested in the area where the seals were taken (Frost, Personal Communication).

Herring have also been reported present in Shishmaref Inlet as early as April and May. Local residents indicate that dead herring can be found in the spring on top of the ice in this area; dead from what they refer to as "died from frosted gills". These herring apparently swim through open ice leads, get caught in the overflow and freeze. Similar observations have also been reported in Golovin Bay.

Relative Abundance

There are only a few sections of coastline where herring surveys have been flown with any consistency prior to OCS studies. These are the

southeastern coastline of Norton Sound and the **Togiak** district of Bristol Bay. Trends in the relative abundance of herring populations have differed between these areas. Estimates of herring abundance from aerial surveys in the **Togiak** area in 1977 revealed some of the largest and most numerous schools ever observed in that area since surveys began in the 1960's (Nelson, Personal Communication). The opposite has been observed in Norton Sound where survey results have indicated a decline in herring abundance. A total of 236 and 137 schools were observed along beaches between St. **Michaels** and **Unalakleet** during 1968 and 1972, respectively. During 1975 and 1976 aerial surveys were intensified, particularly in 1976 when OCS funding was made available. Not more than 10 schools were observed in either year in the same area. In 1977 only a single school was observed. A similar trend was indicated from surveys made in the Cape **Denbigh** area until 1977. Nearly twice as many herring schools were observed at Cape **Denbigh** in 1977 as was observed in 1972, 1975 or 1976. Similar comparative data is not available for other spawning areas along the west coast.

Most coastal residents interviewed in the last two years indicated that herring abundance has declined. The only exceptions were residents interviewed in **Shishmaref**. This possibility is also expressed in the downward trend of foreign herring trawl catches in the Bering Sea between 1968 and 1976.

The relative abundance of herring populations along the west coast of Alaska has been better identified during the course of these studies. Results from this investigation and from studies conducted by Barton et al. (1977) in the southern Bering Sea indicate herring abundance, based upon surface area estimates of school size, is greatest south of the Yukon River with the **Togiak** district in Bristol Bay having, by far, the largest concentrations (Figure 65). The relative abundance of spawning herring north of the Yukon River is greatest in the southern and eastern portions of Norton Sound. Many schools of fish believed to be herring were observed along the north coast of the Seward Peninsula in 1977, but exact identity of all of these schools was not possible.

Spawning Habitat Types

Little can be said about actual herring spawning habitats throughout the study area from the standpoint of extent and density of spawn deposition. Only a limited amount of spawn was actually recovered by ground crews while sampling in 1976 and 1977. However, certain generalizations in reference to spawning habitats can be made. Whereas herring spawning is common throughout the intertidal zones in areas along the west coast of Alaska below the Yukon River, particularly in the **Togiak** area of Bristol Bay (Barton et al. 1977), the greatest percentage of spawning throughout the Norton Sound and **Kotzebue** Sound areas is subtidal although some intertidal spawning does occur. This is basically a function of the relatively small tide changes which occur in these areas. Very little intertidal beach area is available for spawning in contrast to more southern areas. In areas north of **Golovin** Bay (Norton Sound) most spawning occurs in shallow subtidal bays, lagoons and inlets.

There are basically two habitat types utilized by spawning herring in Norton Sound and Kotzebue Sound. Spawning in Norton Sound from Cape Stebbins to Golovin Bay was only observed to occur in areas of exposed rocky headlands. In such areas rockweed kelp (Fucus sp.) was common on rocks in intertidal and/or shallow subtidal zones (Photograph 18). Samples of spawn collected along the southern coastline of Norton Sound from St. Michaels to Tolstoi Point in June 1976 were found deposited on Fucus. A small commercial harvest of herring roe on kelp in Norton Sound in 1977 indicated that Fucus fragactus occurs on the south side of Cape Denbigh. In Golovin Bay, spawning occurred on the east side of Carolyn Island in an area of rocky coastline. Fucus is common in that area but local residents reported that herring spawn was harvested several years ago on bare rocks at Rocky Point. Bluff and Topkok Head are both exposed rocky headlands and are two important spawning areas along the northern coast of Norton Sound. Barton et al. (1977) found herring spawn on bare rock at Nelson Island in 1976 under conditions of dense spawning. Reid (1971b) also indicates that bare rock and most any other substrate is utilized under such conditions.

A distinct change in herring habitats was noticed from Bluff northward to Cape Espenberg in Kotzebue Sound. Where herring spawning was documented in areas along this section of coastline, habitats consisted of relatively shallow bays, lagoons or inlets, such as Imuruk Basin in Port Clarence. Eelgrass (Zosteria sp.) was the most common vegetative type found in Port Clarence, Grantley Harbor or Imuruk Basin and Fucus was not found in these areas. McRoy (1968) also documented Zosteria as being common to the Port Clarence area (Brevig Lagoon).

Dmitriev (1958) states that Pacific herring in the White Sea, which spawn in inlets and bays, deposit eggs in shallow water (2-5 m, mostly 2-3 m) on underwater vegetation such as eelgrass (Zosteria sp.) and less often on Fucus algae, Cladophora and Phyllophora. The White Sea lies at the same latitude as Port Clarence, the northern Seward Peninsula and Kotzebue Sound (Figure 66). Aerial survey results indicated that herring along the northwest coast of the Seward Peninsula from Cape Prince of Wales to Cape Espenberg were entering the shallow lagoons and inlets.

Fishermen from Shishmaref stated that subsistence fishing for herring used to occur in the Serpentine and Arctic rivers in Shishmaref Inlet, but now most effort occurs only at the mouths of these rivers. That herring occur in rivers is not unpalausible, since Galkina (1957) reported that herring in the Sea of Okhotsk, not only enter the estuaries of rivers but also the river proper. Residents of Shishmaref were not familiar with the herring spawning act and those interviewed had never observed eggs on substrate either in the spring or fall in Shishmaref Inlet. However, early spring ice conditions hinder boat travel to this area of Shishmaref Inlet and spawn could easily be overlooked by the time fishing effort begins. Assuming that some spawning does occur in the lagoon areas, spawning habitat is quite typical of that in Imuruk Basin; Zosteria is common, the water brackish and depths very shallow. Herring were only documented to spawn along the north coast of the Seward Peninsula along exposed rocky headlands in eastern Eschscholtz Bay. Other areas where herring are reported to spawn in Kotzebue Sound are in Kugruk and Kiwalik lagoons. Again, these areas are shallow and protected; vegetative types have not been examined.

A major difference exists between herring which spawn in **the** two general types of spawning habitats in Norton Sound and Kotzebue Sound. Herring which spawn from Port Clarence northward are **euryhaline**, being able to tolerate wide-range fluctuations in salinity; more so than stocks which spawn further south. Salinities in **Grantley** Harbor ranged from 2.9-1.9 ppt on July 1, 1977. On July 6, salinities in Port Clarence (near the mouth of **Grantley** Harbor) ranged from 22.0-13.3 ppt, while in **Imuruk** Basin on July 10, two readings were made; 1.3 and 2.3 ppt. **Alt** (1971) also found a similar steep gradient in salinities in July 1970 in the Port Clarence area: In **Imuruk** Basin salinities ranged from 3.8-5.4 ppt, in **Grantley** Harbor 23.4 ppt; and, in Port Clarence they ranged from 28.5-29.7 ppt. Although no salinity measurements were obtained in **Shishmaref Inlet**, low readings would be expected due to the influx of fresh water from the **Serpentine** and **Arctic** rivers. Herring occurring in these areas are also probably **eurythermal** as well as **euryhaline** since over-wintering occurs in these areas. **Dmitriev** (1958) stated **White Sea** herring were both **euryhaline** and **eurythermal**.

Age and Growth

Length-at-age data collected from herring spawning stocks in **Golovin** Bay and Port Clarence in 1977, revealed Port Clarence stocks to be significantly smaller than those in **Golovin** Bay (Figure 67). Mean standard length for Age V herring (the predominant spawning age class in 1977) in Port Clarence and **Golovin** Bay was 183 mm and 220 mm, respectively; a difference of 37 mm. This was the average difference in mean length-at-age for Age Classes I through X between the two areas in 1977.

A comparison of length-at-age data on herring spawning stocks along the western North America coast from British Columbia to the Seward Peninsula in Alaska **reveales** that size increases from south to north into northern **Bristol Bay** and the **Yukon-Kuskokwim Delta**. Stocks north of this area become significantly smaller in Norton Sound and Port Clarence (Table 45 and 46).

No samples have been obtained from the Kotzebue Sound area apart from some collected offshore in 1976 (**Wolotira** et al. 1977). **Wolotira** found age groups II through IV to predominate both north and south of the Bering Strait, with older-aged fish more numerous in the **Chukchi** Sea and younger ages south of the Bering Strait. Overall, fish less than 110 mm accounted for 3% of his population estimate in numbers, 120-200 mm fish accounted for 83% and fish larger than 200 mm comprised 14% of the estimated population. He stated that "Pacific herring. . .displayed greater lengths-at-age and maximum sizes south of Bering Strait than to the north"

Growth rate of Age 0 herring captured in Port Clarence in 1977 was estimated at about 1.4-1.7 mm per day from late August to late September. No growth information was available on herring taken in **Golovin** Bay in that year. However, growth of older-age herring (**IV-V+**) appears to be greater in **Golovin** Bay than in Port Clarence, while similar growth

occurred among young herring in both areas (Figure 67). Wespestad (1978) reported herring stocks in the Bering Sea to grow at about the same rate as stocks in the Gulf of Alaska and British Columbia until ages III-IV, with faster growth of older fish in the Bering Sea as opposed to more southern stocks.

Stock Considerations

Svetovidov (1944) classified subspecies of oceanic herring on the basis of vertebral counts. He states that the subspecies may be assigned to one of two groups, those with high vertebral counts and those with low. He found in his investigations that the two groups also differ in cranium width. The Atlantic and Baltic herrings belong to the narrow-headed, high vertebral count group; the White Sea, Chosha and Pacific herrings to the wide-headed, low vertebral count group. He points out that forms with low vertebral counts are the most euryhaline.

Rounsefell (1930) examined herring samples from San Diego to Golovin for vertebral counts and several other meristic comparisons. In his summary on vertebral counts he stated that following the general trend of the coastline northward and westward from San Diego, mean vertebral counts increased with distance, being practically linear and widely departed from only by herring of the Shumagin Islands and Golovin Bay. Vertebral counts increased from south to north from San Diego to the Shumagin Islands, then decreased from there northward to Golovin Bay (Table 47). A similar trend has been shown to exist based upon mean length-at-age data presented earlier. Rounsefell concluded from the analysis of all characters examined that several distinct herring stocks existed along the west coast of North America with Golovin Bay herring listed as one.

The mean vertebral count of Golovin Bay herring sampled by Rounsefell was 52.79. Averinzev (1926, not seen by author, cited from Rounsefell 1930) indicated that the average vertebral count of different "races" of herring in the White Sea vary from 52.14 to 56.18. Dmitriev (1958) states there are two forms of herring in the White Sea: A large form, Clupea harengus pallasii maris-albi major and a small form as C.h.p. maris-albi minor. Consequently, it can be assumed that Rounsefell's Golovin Bay herring samples were quite similar to the small form of White Sea herring based upon vertebral counts.

OCS studies indicate that herring populations from Golovin Bay northward differ significantly from herring populations occurring from southern Norton Sound and southward into the southern Bering Sea in size and behaviorial characteristics. Differences between these two regions are summarized as follows:

Seward Peninsula Populations	South Norton Sound to southern Bering Sea populations
Smaller herring with lower vertebral counts.	Larger herring with probable higher vertebral counts.
Lower abundance.	Higher abundance.

Subtidal spawning (3m) in shallow bays, inlets & lagoons.

Intertidal and shallow **subtidal** spawning along exposed rocky headlands.

Zosteria sp. primary spawning substrate.

Fucus sp. primary spawning substrate.

More **euryhaline**.

Less **euryhaline**.

Overwinter in shallow bays; water is warmed by river discharge under ice cover.

Overwinter in deep ocean layers near the **Pribilof** Islands.

Fall (non-spawning) runs documented.

No fall runs documented

Larval development in brackish water.

Larval development probable in more saline water.

Data collected from herring populations along the Seward Peninsula during OCS studies strongly indicate that independent stocks of herring occur in this region. This does not preclude the possibility of the occurrence of more southern stocks from utilizing this region, i.e., those stocks described by Dudnik and **Usol'tsev** (1964), Saboneev (1965) and others, which winter near the **Pribilof** Islands and migrate to the western Alaska coast to spawn. It is unlikely however, that herring stocks along the Seward Peninsula migrate to the central Bering Sea for wintering, but rather remain in coastal lagoons, bays or inlets. These stocks closely parallel some of the White Sea small herring which exhibit a similar behavior. They remain in shallow bays and inlets which are warmed by river discharge under the ice. This in itself is probably a major factor in explaining size differences, i.e., environmental conditions. Water temperatures and feeding conditions in deep ocean waters are probably more favorable for growth than those prevailing in herring winter habitats along the Seward Peninsula, which apparently (like the White Sea herrings) have become adapted to Arctic conditions.

Salmonidae (Salmon and Trout)

Six species of **salmonids** were captured during the course of these studies: Arctic char, chum salmon, pink salmon, coho salmon, king salmon and sockeye salmon. All five species of Pacific **salmon** are indigenous to the Norton Sound area with chum salmon being the most abundant. Pink salmon are second in abundance followed in order by **coho**, king and sockeye salmon.

Commercial salmon fishing provides local residents with a major source of employment and first began in eastern Norton Sound in 1961. Although early effort was primarily stimulated by interest in king and coho salmon, chum salmon are now the most important commercial species followed by pink salmon. General run timing of adult salmon in Norton Sound and the Port Clarence area is as follows (**ADF&G** 1976):

Species	Present in bays and estuaries	Spawning
King	June 15 to July 10-15	July 10 to August 5
Sockeye	June 25 to July 25	July 15 to September 10
Coho	August 1 to August 20	August 20 to Sept 30
Pink	June 25 or July 1 to July 15-20	July 15 to August 5
Chum	June 20-25 to July 20-25	July 10 to August 15

Commercial salmon fishing since its inception in Norton Sound has extended annually from June 1 to September 30. Commercial fishing in the Port Clarence area only occurred in 1966 and 1,266 adult salmon were taken in the **Grantley Harbor - Tuksuk Channel** area. Since that time salmon have been harvested exclusively in this area for subsistence purposes. A unique feature of the Port Clarence area is the Pilgrim River sockeye salmon run, one of the northernmost occurrences of this species in North America.

In 1976, no sampling was conducted during about a two to three week period of open-water immediately following ice breakup (Barton 1977). In 1977, sampling commenced with the onset of ice breakup to examine the early open-water period for occurrence of juvenile salmon. The only significant catches made that year were in **Golovin Bay**. Data obtained on juvenile salmon in the southern and eastern portion of Norton Sound in 1977 are inconclusive in that no significant catches were made. However, this is partially explained by sampling coverage in that area. The **Unalakleet** crew was responsible for sampling 205 km of exposed coastline as opposed to the more protected and smaller waters of **Golovin Bay**. Consequently, much more time was required for the **Unalakleet** crew to "adequately" sample their area due to inclement weather problems and distances involved.

All information collected during the course of these studies on juvenile pink and chum **salmon** indicate they are present in nearshore coastal waters of Norton Sound with the onset of ice breakup and remain present until about the second week of July. It should be realized however, that juvenile salmon were primarily captured with beach seines, being too small for **gillnets** early in the season. Our findings suggest that juveniles vacate the immediate onshore littoral area by mid-July. Since no juveniles were captured in any gear type from mid-July until freezeup in nearshore waters, it is probable that they migrated offshore to more **pelagial** regions. This is interesting as **McPhail** and Lindsey (1970) and Hart (1973) indicate that both species generally remain nearshore until about September when they depart for deeper water. The mean surface water temperature in **Golovin Bay** during the last two weeks of June in 1977 was 12.0°C and 12.8°C in the first two weeks of July.

Information obtained on growth of both juvenile pink and chum salmon in Norton Sound indicates very similar growth rates (Table 23). This is

not surprising since the diets and feeding habits of these species is basically the same (McPhail and Lindsey 1970; Hart 1973; and others). Growth rates of pink and chum salmon juveniles from Golovin Bay during the period from ice breakup until mid-July 1977, exhibited a 2.5% increase in growth per day. Offshore marine growth was examined using both 1977 length data and 1976 length information collected by Wolotira et al. (1977). Only four juvenile pink and two juvenile chum salmon were captured in offshore waters in the first week of September 1976. Examination of length differences shows a 3.3% and 3.4% increase in growth per day for pink and chum salmon juveniles, respectively, from mid-July until early September. Overall from breakup until September the growth rate was 4.6% and 4.7%, respectively for juvenile pink and chum salmon. In comparison, daily growth rates of Age 0 herring in Port Clarence were about 3.5-4.0% from late August to early October.

Arctic char was the sixth salmonid captured in the study area. It was the most widespread species encountered being present in all areas sampled in both 1976 and 1977. Bendock (1977) found this species widely distributed throughout the coastal waters of the Beaufort Sea from Harrison Bay to Haxman Island, while Kendel et al. (1975) found the distribution of Arctic char to be mainly concentrated from Hershal Island to Point Kay off the MacKenzie River Delta. Char at sea are known to cover great distances (Griffiths et al. 1975, not seen by author, cited in Kendel et al. 1975). Consequently, populations of char throughout the coastal waters of Norton Sound are likely a mixture of stocks from various rivers, the degree to which is not known.

Beach seines captured char ranging in size from 99-640 mm with a mean of 297 mm and standard deviation of 168.9. A distinct mode was observed between 160 and 169 mm. Gillnet samples ranged from 139-598 mm with a mean of 404 mm and standard deviation of 85.2 mm. Two distinct modes represented in these samples occurred between 390-399 mm and 450-459 mm. It is apparent that gillnets selected toward the older and larger char (Figure 38). No char were captured in beach seines after June 21 in the Golovin Bay and eastern Norton Sound areas while none were captured with beach seines in the Port Clarence area after July 21. These findings suggest that smaller (younger) char were not present about one month after ice breakup in the immediate littoral zone when considering breakup in Port Clarence occurred one month later than in the remainder of Norton Sound. It is also interesting to note that no char were captured in any area with offshore sinking gillnets suggesting they were primarily confined to the immediate shoreline surface waters in the coastal areas.

Eleven char were captured with floating gillnets from June 22 through July 7 in the offshore surface waters of Norton Sound in 1977. Lengths ranged from 149-485 mm with a mean of 292 mm and standard deviation of 118.3. Eight arctic char captured in the offshore waters in 1976 from September 2 through October 9 had lengths ranging from 242-259 mm with a mean of 250 mm and standard deviation of 6.8.

Fork lengths ranged from 154-685 mm with a mean of 427 mm on 3,739 Arctic char captured by Bendock (1977) in 1975 and 1976. He states a length mode occurred between 520 and 529 mm, and further, that juveniles

less than 200 mm were abundant in nearshore waters between the Colville and Sagavanirktok rivers during the open water season. Our studies indicated that juveniles less than 200 mm were not present in the coastal waters in significant numbers approximately one month after ice breakup.

Arctic char were most abundant in the eastern section of Norton Sound, particularly between Cape Denbigh and Tolstoi Point (area B and C). In general, char catches decreased as the season progressed into the Fall in all areas examined.

Stichaeidae (Pricklebacks)

Two members of the family Stichaeidae were captured during the course of our investigations; snake prickleback and pighead prickleback (Figure 80). These species were primarily captured in nearshore waters of southern and eastern Norton Sound from Cape Stebbins to Cape Denbigh. Their frequency of occurrence was 5% and 18% in gillnets and beach seines, respectively. Total abundance was relatively low, comprising only 2.4% of all species captured in that area. The only other area where prickleback were captured was between Rocky Point and Bluff (Area F) when six juveniles (species unknown) were captured in late July 1976.

Wolotira et al. (1977) found five members of this family widely distributed offshore in Norton Sound and the southern Chukchi Sea in the fall of 1976. The snake prickleback was not found in their catches. They found that Stichaeidae, together with Zoarcidae (eelpouts) and Agonidae represented only about 5% of the total fish biomass within their study area.

Seventy-one length samples collected from southern and eastern Norton Sound in 1977 from beach seines had a range of 208-420 mm with a mean of 294 mm and standard deviation of 50.5. Two pricklebacks caught in gillnets measured 234 mm and 235 mm. Certain species of Lumpenus are apparently a prime factor in determining colony size and nesting success of many sea birds throughout the study area (Drury, personal communication). Kittiwakes at Bluff produced about one chick per two nests in 1975 and one chick per 50 nests in 1976. Drury suggested this difference to have been due to differences in food supply between July 5-20. He indicated similar affects seemed to have occurred with murre and puffins and that sand lance and one species of Lumpenus are the main food for Common Murres, Horned Puffins and Kittiwakes.

Larval Lumpenus species were captured in the surface waters of several offshore stations sampled by the Royal Atlantic from June 22 through July 7, 1977 (Figure 48).

Ammodytidae (Sand Lance)

Sand lance were the most abundant fish captured in either 1976 or 1977 in absolute numbers. Although widely distributed throughout Port Clarence and Grantley Harbor (Figure 71), they were most abundant in the Golovin Bay and Bluff areas (Areas A and F), comprising 80.8% of the entire catch composition of all species in those areas (Figure 68). They were found infrequently and at low abundance in the southern and eastern portions of Norton Sound coastal waters being captured at only two locations: Klikitarik and Egavik.

Sand lance were present in significant numbers and most abundant in the Golovin Bay area from July 7-September 21 (Period 3-7) (Table 28). Only a few were present during Periods 2 and 8 with none captured in Period 1 (June 7-21) or Period 9 (October 7-21). Examination of 1977 length frequencies revealed the presence of large sand lance in the spring while smaller ones occupied nearshore waters in summer and fall (Figure 31). Three distinct modes were present during these seasonal periods: 80-84 mm in spring (May 29-July 21); 50-54 mm in summer (July 22-September 6); and, 60-64 mm in fall (September 7-October 21). Mean lengths were 83 mm, 59 mm and 63 mm, respectively. A mode existed at 65-69 mm from 456 length samples collected from July 7 through September 21, 1976 in this same area. The mean length was 64 mm.

The reproductive cycle of this species in the northeast Bering Sea is virtually unknown. However, larval sand lance were captured in the surface waters of several offshore stations during the Royal Atlantic cruise from June 22 through July 7, 1977 which suggests that spawning occurs in late May-early June (Figure 48).

Osmeridae (Smelts)

Osmeridae were represented by three species: Boreal smelt, pond smelt and capelin. This family ranked third by frequency of occurrence in beach seine catches and fifth in gillnet catches throughout the coastal waters of our study region. Boreal smelt were the most abundant and widely distributed **Osmeridae** throughout the surface waters of the study area in both 1976 and 1977. They were the most frequently encountered species in beach seines for all areas combined (44.2%), while ranking first (75%) in southern and eastern Norton Sound and fourth in both Golovin Bay (31%) and the Port Clarence area (32%) (Tables 48 and 49).

Pond smelt were the most frequently encountered species in Port Clarence (57%) and ranked sixth in overall frequency of occurrence (24.1%) for all areas combined. They made up the greatest percent composition (68.1%) of all species captured in the Port Clarence area (Figure 68). Although both boreal smelt and pond smelt were widely distributed throughout the Port Clarence and Golovin Bay areas, pond smelt were primarily restricted to the vicinity of the Unalakleet River in the coastal waters of eastern Norton Sound. In this area boreal smelt were the most abundant while pond smelt were the most abundant in the Port Clarence area. The percent composition of species in the Port Clarence area was 68.1% for pond smelt and 2.5% for boreal smelt, while in the southern and eastern sections of Norton Sound boreal smelt consisted of 36.8% and pond smelt 1.1% of the species composition. In Golovin Bay the percent composition was about the same for both species being 2.2% for boreal smelt and 2.0% for pond smelt (Figure 68).

Results of offshore sampling in Norton Sound in the southern Chukchi Sea in 1976 by Wolotira et al. revealed boreal smelt to be widely distributed throughout the entire region in September and October. This species ranked fourth in frequency of occurrence of all species captured in

demersal trawls and ranked fifth in abundance. The percent occurrence of boreal smelt in demersal trawls was 57% and 71% in the Chukchi Sea and Norton Sound areas, respectively. They also found that boreal smelt were the most abundant and frequently occurring species captured with variable mesh gillnets in offshore surface waters of Norton Sound and the southern Chukchi Sea for the same time period. Only a single pond smelt was captured in floating gillnets and none in demersal trawls. Alverson and Wilimosky (1966) reported the presence of juvenile osmerids in midwater sets below the thermocline in offshore waters of northern Kotzebue Sound in August 1959. Only two osmerids were identified during his studies: boreal smelt and capelin.

Beach seines and gillnets sampled different size frequencies of several species in nearshore waters in 1977. Small smelt were sampled with beach seines while gillnets were more selective toward larger smelts (Figures 32 and 33). The mean length for boreal smelt and pond smelt captured in beach seines throughout the entire study period was 49 mm and 55 mm, respectively. Mean lengths of boreal smelt and pond smelt captured in gillnets were 185 mm and 118 mm, respectively. Wolotira et al. (1977) found that fish less than 200 mm comprised nearly the entire population of boreal smelt captured in demersal trawls in 1976 although appreciable numbers of boreal smelt larger than 200 mm occurred in outer Norton Sound south of Port Clarence. He reported that in general, average size of boreal smelt was less in shallow water nearshore as opposed to deep offshore regions.

Larval boreal smelt were frequently encountered during our studies throughout the entire study area in the nearshore waters of Norton Sound (Figure 81). They were captured as late as Period 2 (August 22-September 6) in Golovin Bay and Period 7 (September 7-22) in Grantley Harbor. Larval pond smelt were captured in Imuruk Basin as late as October 6. Larval osmerids were also found present from June 9 through July 7 in the offshore surface waters of Norton Sound in 1977. Neimark (Personal Communication) found larval smelt (Osmerus eperlanus) to be the most important teleostid in diets of several species examined in Norton Sound in 1976.

All information collected indicates that boreal smelt have a wider distribution throughout the marine waters of Norton Sound as opposed to pond smelt, which showed a greater affinity for nearshore brackish waters. Boreal smelt were captured in pelagic and nearshore waters from breakup through freezeup at various stages of development. This is contrary to Warner and Shafford (1977) who hypothesized that boreal smelt do not migrate to sea in great numbers, subjecting themselves to "riggers of the open marine tropic system". They identified boreal smelt as being principally a species of estuarine habitats.

A fall run of adult boreal smelt was observed in October 1977 in the Imuruk Basin area. Large numbers of adult boreal smelt were captured for subsistence purposes in the Tuksuk Channel in that month.

Only four capelin were collected throughout the entire study period, two of which were taken in a beach seine haul made in July 1976 near Tolstoi Point in southeastern Norton Sound. Two other specimens were taken in 1977: one at Jones Spit and one near the Tuksuk Channel in Grantley

Harbor. Residents of Teller were shown these samples and no one interviewed had ever seen this species before. Similar results were obtained in Shishmaref when samples of **capelin** were shown to residents there.

A single male **capelin** carcass (spawner) was found immediately in front of Nome by the breakwater on August 3, 1976 indicating some spawning occurred in that year. An aerial survey of the beaches from Penny River to Cape Nome on August 4 did not reveal the presence of additional **capelin** carcasses. That same day a ground reconnaissance of the coast from the Nome jetties to Penny River also resulted in no observations of **capelin**. It was assumed that if any spawning in this area was occurring, it was away from the immediate shoreline in **subtidal** waters. Wind conditions were such that if spawning in any significant numbers had occurred in the surf areas of the shoreline that more carcasses would have in **all** probability been present **along** the beaches.

Barton et al. (1977) found that primary **capelin** spawning **habitats along** the west coast of Alaska consisted of relatively smooth sand and **gravel** beaches. Areas of this type predominantly occur on the Seward Peninsula from near Bluff to Port Clarence and from Cape Prince of **Wales** to Cape - **Espenberg**. At least two residents of Nome indicated that appearance of **capelin (cigarfish)** along the beaches of Nome in the vicinity of Fort Davis is not an annual occurrence. A spawning run was documented to have occurred in this area at the end of June in 1974 (**Grauvogel** ADF&G, Personal Communication and other residents), although no records were found in ADF&G files to this affect. However, many ADF&G records were destroyed during the 1974 Nome flood.

Most information available on **capelin** distribution in the study area was obtained by **Wolotira** et al. (1977). Only trace amounts were encountered, mostly in offshore and deeper waters and total estimated biomass was 190 metric tons (+ 91 mt @ 95%). More than 52% of this amount was found in offshore waters between St. Lawrence Island and Port Clarence. An additional 34% was distributed in the offshore waters of northern **Kotzebue** Sound south of Point Hope. **Alverson** and **Wilimosky (1966)** also found **capelin** present in **demersal** trawls in northern **Kotzebue** Sound and as far north as above Cape Lisburne in offshore waters during August 1959.

Indications are that although **capelin** are present in our area their abundance is relatively low especially when compared to areas in the southern Bering Sea.

Gadidae (Cods)

Two members of the **Gadidae** family were captured in nearshore waters **during** our studies. The only freshwater member of this family, burbot, was captured only in the Yukon River Delta area. **Alt (1971; 1972)** captured a **single burbot** in **Imuruk** Basin in **July 1970** and **three** more specimens in the **Agiapuk** River delta in 1971.

Burbot are an important subsistence food item in the Yukon River. Data presented by Crawford (June 1978, unpublished report) indicate peak

subsistence catches of **burbot** occur in February, although they are taken in the lower reaches of the Yukon River (Russian Mission and downriver) throughout the winter months. A run of juvenile **burbot** down the Yukon River was documented at the mouth of the Anuk River to occur during the first week of July in 1977. This downstream migration coincided with downstream migrations of juvenile **sheefish** and juvenile whitefish.

Saffron cod was the second gadid captured during our studies. It was the most frequently encountered species in **gillnet** catches (30.877) and the second most frequently encountered in beach seines (42.4%). It was one of the most widely distributed species throughout the entire study area. Crawford (January 1978, unpublished report) indicates this species is taken for subsistence purposes by local residents in September and October at **Kotlik**, Sheldon's Point, **Alakanuk** and Emmonak. This species was not captured in the Flat Island area in 1976 during our investigations. Saffron cod is a major subsistence food item to local residents throughout the study area.

The percent composition of saffron cod captured in the nearshore waters of Norton Sound was 4.6%, 2.1% and 17.1% in the Port Clarence, **Golovin** Bay and southern and eastern Norton Sound areas, respectively (Figure 68). Table 37 shows the selectivity of **gillnets** to larger (older) saffron cod as opposed to beach seines. Saffron cod length samples from beach seine catches range from 32-358 mm with a mean of 112 mm and standard deviation of 63, while lengths from **gillnet** samples range from 92-420 mm with a mean of 252 mm and standard deviation of 50.7. An examination of catch per unit effort values in Table 55 reveal seine catches were in general greatest in all areas during Periods 4-6 (July 22-September 6), while **gillnet** catches held fairly consistent from breakup through freezeup.

Wolotira et al. (1977) reported saffron cod as the most abundant fish species encountered in September and October 1976 during offshore surveys of Norton Sound and the southern **Chukchi** Sea. The frequency of occurrence of saffron cod in **demersal** trawls was 78% and it represented 45% of the total apparent biomass of all fish species combined during their studies. They found that, although most saffron cod encountered north of Bering Strait were small, the highest relative abundance for young saffron cod was in Norton Sound. Their investigation showed that saffron cod ranging from 130-250 mm comprised about 25% of their estimated population in the study area.

No other gadids were found in nearshore waters in 1976 or 1977, although three additional members of the **Gadidae** family were captured in the offshore waters by **Wolotira** et al. Saffron cod therefore show a stronger affinity to frequent brackish/freshwater areas (excluding **burbot**) than the other gadids present in our study area.

Larval **finfish** were the most frequently encountered (66%) organism in the offshore surface waters of Norton Sound in June, 1977. Of these, gadid larvae were among the most frequently encountered and widely distributed (Figure 48). These larval gadids were identified to be saffron cod.

Pleuronectidae (Flat Fishes)

Pleuronectidae was the second most frequently encountered fish family in our area in both beach seines (71%) and **gillnets** (39%) (Table 50). Starry flounder was the most widespread and frequently encountered species followed by Arctic flounder (Figure 75; Tables 48 and 49). These two species made up a higher percentage of the species catch composition in southern and eastern Norton Sound (7.8%) than in any other area (Figure 68). Starry flounder were the only **flatfish** species encountered in slightly brackish water such as Imuruk Basin, the **Unalakleet** River lagoon and the Yukon River Delta.

Alaska plaice, **yellowfin** sole and longhead dab were the three other species represented by this family. Of these, **yellowfin** sole was captured only in **Golovin** Bay and southeastern Norton Sound, while Alaska plaice were distributed in all areas except the Yukon River Delta. Longhead dab were only captured in 1976 in eastern Norton Sound from Cape **Denbigh** to the **Unalakleet** River (Figure 78). These three species were relatively low in abundance in nearshore waters when compared to starry flounder and Arctic flounder.

Wolotira et al. (1977) found all five of these species common in offshore **demersal** trawls in September and October 1976 in Norton Sound and the southern **Chukchi** Sea. Starry flounder were also found in offshore surface waters in 1976 and 1977.

The only **flatfish** species encountered in nearshore waters of the Beaufort Sea by **Bendock** (1977) was Arctic flounder, while **Kendel** et al. (1975) found both Arctic flounder and starry flounder present in his studies along the coast of the Yukon Territory in Canada.

Coregonidae (Whitefishes)

Six species of **coregonids** were encountered during our studies. This family of fish was more frequently encountered than any other in both beach seines (96%) and **gillnets** (58%). They were represented by two **anadromous** and four freshwater forms: Bering **cisco** and **least cisco** (**anadromous**); **Innconu**, broad, humpback and round whitefish (freshwater). **Ciscos** were among the ten most frequently encountered species in all areas, with Bering **cisco** being, generally, more frequently encountered than **least cisco**.

Bering **cisco** had a slightly wider distribution throughout the coastal waters of Norton Sound and were found to be much more common than **least cisco** in the Flat Island study area (Figures 73 and 82). Bering **cisco** were also captured in offshore surface waters of Norton Sound in the fall of 1976 and spring of 1977. This data suggests that **least cisco** in our study area have a greater affinity for brackish waters of the mainland coast. **Bendock** (1977) also documented a similar finding among **least cisco** populations along the north Alaska coastline in the Beaufort Sea.

Gillnets were selective to large **ciscos** while beach seines sampled both larger and smaller fish (Figures 34 and 35). Bering **cisco** sampled in the Port Clarence area were larger than either **Golovin** Bay or southeastern

Norton Sound samples. The mean length of Bering **cisco** in Port Clarence was 239 mm for beach seines and 285 mm for gillnets. Lengths of Bering **cisco** captured in beach seines in Golovin Bay and the southern and eastern portion of Norton Sound were 142 mm and 122 mm, respectively. Mean lengths of **gillnet** catches for these two areas was 212 mm and 218 mm respectively. The largest individuals were captured in the spring in all areas.

Ciscos comprised 3.5%, 2.0% and 6.5% of the species catch composition in Port Clarence, Golovin Bay and southeastern Norton Sound, respectively. Percent composition of **ciscos** in the Flat Island area was 43%. They were present in all areas in the nearshore waters throughout the entire sampling season.

Humpback whitefish displayed a wider distribution in nearshore coastal waters, followed in order by broad whitefish and round whitefish (Figures 72 and 83). The broad whitefish was common to Port Clarence and Golovin Bay, but its distribution was more restricted in the southeastern portion of Norton Sound being primarily confined to coastal waters south of the Unalakleet River. Round whitefish were only captured in the Port Clarence area and in nearshore waters of southeastern Norton Sound between Unalakleet River and Tolstoi Point. Humpback and broad whitefish showed a greater distribution in brackish and coastal marine waters than round whitefish. These three species were less frequently encountered than either of the **ciscos** in all areas examined. Abundance of these three species was greatest in slightly brackish to near freshwater areas and their presence did not appear to be seasonal.

The only other coregonid captured in our studies was **Inconnu**. This species was only found in the Yukon River (Figure 84), although resident populations are also known to occur in the Kobuk River in Norton Bay (Alt 1977). Also, scattered catches of this species have been made at various locations along the Norton Sound coast (Geiger, ADF&G, Personal Communication).

Juvenile **Inconnu** were captured in June, 1977, 101 kilometers upriver from Flat Island in the Yukon River. Fork lengths ranged from 35-74 mm with a mean of 56 mm. A downstream migration of this species was documented to occur during the first week of July. Timing coincided with downstream migrations of juvenile whitefish and juvenile **burbot**. A total of 557 fork length measurements of juvenile whitefish (juvenile humpback and broad whitefish) ranged from 20-51 mm. The mean length from 89 of these samples was 34 mm.

Other Fish Species

Eight other families of fish were captured during our investigations: Esocidae, Catostomidae, Agonidae, **Cottidae**, Gasterosteriidae, Hexagrammidae, Liparidae and Anarhichadidae. Northern pike and northern sucker were only found in two areas examined; Imuruk Basin in the Port Clarence area and in the Yukon River Delta. Only a single specimen of these two species was captured in Imuruk Basin in 1977 while both species were widely distributed throughout the Flat Island study area at the south

mouth of the Yukon River (Figure 85). Northern pike are taken for subsistence use by villages along the lower part of the Yukon River in the fall and early winter months. Crawford (June 1978, unpublished report) showed subsistence catches in nine villages throughout the period October 1977 through March 1978. A peak catch of 152 northern pike was reported in October, although fishing effort in these villages peaked in November. The total catch in November was 145 fish.

Three members of the family Agonidae were captured: Tubenose poacher, Bering poacher and sturgeon poacher. Tubenose poachers were the most widely distributed throughout Norton Sound coastal waters followed closely by Bering poacher (Figure 76). Sturgeon poachers were the least abundant and frequently encountered Agonidae; being found at only a single station in Golovin Bay and another at the mouth of Wagonbox Creek in southern Norton Sound. All three of these species were captured by Wolotira et al. (1977). They found sea poachers widely distributed throughout both Norton Sound and the southern Chukchi Sea. Sturgeon poachers ranked sixth by frequency of occurrence (62%) and 17 by abundance (0.03 kg/km). Larval sea poachers were present in June in the offshore surface waters of Norton Sound and Port Clarence in 1977.

Both threespine and ninespine sticklebacks were present in the study area with ninespine sticklebacks being among the most widely distributed species (Figure 77). This species was also found in the surface waters of Norton Sound in June 1977 between Cape Denbigh and Cape Darby. Ninespine sticklebacks were more widely distributed in marine waters than threespine sticklebacks and were the fifth most frequently occurring species (25.5%) sampled within beach seines.

Threespine sticklebacks were only found in the Port Clarence area with the exception of a single specimen captured in Golovin Bay in August 1976. Threespine sticklebacks appeared to be primarily confined to marine estuaries of relatively low salinity. Thus, ninespine sticklebacks appeared to be more tolerant of marine waters. Wolotira et al. (1977) also documented ninespine sticklebacks in demersal trawl catches in 1976.

Several species of cottids were present in the study area and this family (Cottidae) ranked eighth and ninth by frequency of occurrence of all families sampled in gillnets and beach seines, respectively. In contrast, Wolotira et al. (1977) reported this family ranked third in estimated biomass susceptible to trawls of all fish species captured during offshore demersal sampling of Norton Sound and the southern Chukchi Sea in 1976. Overall, this family constituted only 2% of the estimated biomass of all fish and invertebrae taxa captured in offshore demersal regions. Larval cottids were common in the offshore surface waters of Norton Sound in June 1977.

The distribution of whitespotted greenling and rock greenling in nearshore waters differed (Figure 79). Rock greenling were present in Port Clarence, Golovin Bay and southeastern Norton Sound between Tolstoi Point and the Unalakleet River. In contrast, whitespotted greenling were primarily confined to the Golovin Bay area. This species was found at only one other area; just north of Tolstoi Point. The family Hexagrammidae ranked seven by frequency of occurrence of all families captured in

gillnets. However, in no area did species of this family constitute more than 0.4% of the total catch composition. Frequency of occurrence and relative abundance of rock **greenling** was greatest in southeastern Norton Sound. **Wolotira et al.** (1977) reported only the whi **tespotted greenling** was captured during their surveys in September and October 1976.

Bering **wolffish** were documented only in Port Clarence and **Golovin Bay**. Only three adult specimens were obtained in nearshore waters. Three juvenile wolffish (42 mm, 42 mm and 50 nun) were captured in offshore surface waters of Norton Sound in June 1977 (Figure 48). This species was also taken in **demersal** trawls in the offshore waters of Norton Sound and the southern Chukchi Sea in September and October 1976 (**Wolotira et al.** 1977).

A single **liparid (ringtail snailfish)** was captured in August 1976 in eastern Norton Sound. Larval **lipards** were captured in offshore surface waters of Norton Sound as far north as Cape Prince of **Wales** in June 1977.

AREAS OF CONCERN AND NEEDS FOR FURTHER STUDY

It is not within the scope of this paper to determine the possible or probable impacts of oil pollution on fishery resources in our study area. However, we attempt to point out and identify possible areas of concern where further studies may be warrented.

Hayes et al. (1977) derived a scale of environmental susceptibility to oil spill impacts on the basis of two case studies: The **Metula** spill in the Strait of **Magellan** on August 9, 1974 and the **Urguiola** spill along the northwestern coast of Spain on May 12, 1976. Their scale relates primarily to the longevity of oil in each environment and is listed below in order of increasing susceptibility to oil spills.

1. Straight, rocky headlands:

"Most areas of this type are exposed to maximum wave energy. Waves reflect off the rocky scarps with great force, readily dispersing the oil. In fact, waves reflecting off the **scarps** at high tide tend to generate a **surficial return** flow that keeps the oil off the rocks." Herring spawning in much of Norton Sound is associated with this habitat type and may be typified by such areas as Cape **Denbigh**, Bald Head and Bluff.

2. Eroding wave-cut platforms:

"These areas are also swept clean by wave erosion. All of the areas of this type at the **Metula** spill site had been cleaned of oil after one year. The rate of removal of the oil would be a function of the wave climate. In general, no clean-up procedures are needed for this type of coast."

3. Flat, **fine-grained** sandy beaches:

"Beaches of this type are generally flat and hard-packed. Oil that

is implaced on such beaches will not penetrate the fine sand. Instead, it usually forms a thin layer on the surface that can be readily scraped off by a motorized elevated scraper or some other type of road machinery. Furthermore, these types of beaches change slowly, so burial of oil by new deposition would take place at a slow rate."

4. Steeper, medium to coarse-grained sandy beaches:

"On these beaches, the depth of penetration would be greater than for the fine-grained beaches (though still only a few centimeters), and rates of burial of the oil would be greatly increased. Based on earlier studies... it is possible for oil to be buried as much as 50-100 cm within a period of a few days on beaches of this class. In this type of situation, removal of the oil becomes a serious problem, inasmuch as it would be necessary to destroy the beach in order to remove the oil... Another problem is that burial of the oil preserves it for release at a later date when the beach erodes as part of the natural beach cycle, thus assuring long-term pollution of the environment."

5. Impermeable muddy tidal flats (exposed to winds and currents):

"One of the major surprises of the study of the Metula site was the discovery that oil did not readily stick to the surfaces of mud flats. Also, penetration into the sediments was essentially non-existent. Therefore, if an oiled tidal flat is subject to winds and some currents, the oil will tend to be eventually removed, although not at the rapid rate encountered on exposed beaches." Typical examples of this habitat type include the Yukon River Delta and the Unalakleet and Shaktoolik rivers in eastern Norton Sound.

6. Mixed sand and gravel beaches:

"On beaches of this type, the oil may penetrate several centimeters, and rates of burial are quite high (a few days in Spain). The longevity of the oil at the Metula site, particularly on the low-tide terraces and berm top areas, attests to the high susceptibility of these beaches to long-term oil spill damage." A large majority of the beaches in Norton Sound are of this type.

7. Gravel beaches:

"Pure gravel beaches have large penetration depths (up to 45 cm in Spain). Furthermore, rapid burial is also possible. A heavily oiled gravel beach would be impossible to clean up without completely removing the gravel." Most of the Seward Peninsula coastline falls into this class.

8. Sheltered rocky headlands:

"...Oil tends to stick to rough rocky surfaces. In the absence of abrasion by wave action, oil could remain on such areas for years,

with only chemical and biological processes left to degrade it." Few areas in Norton Sound can be found with this type of coastal morphology; most rocky coasts are exposed.

9. Protected estuarine tidal flats:

"Once oil reaches a backwater, protected, **estuarine** tidal flat, chemical and **biogenic** processes must degrade the oil if it is to be removed." Much of the Seward Peninsula coastline from Golovin Bay to Kotzebue Sound is characterized by **embayments** and inlets which fall into this class. They represent an important habitat type for spawning herring in these areas. It is probable that removal by chemical and **biogenic** processes would proceed at a slow rate in cold environments.

10. Protected estuarine salt marshes:

"In sheltered estuaries, oil from a spill may have long-term deleterious effects. . . . Oil from the **Metula** on the salt marshes of East Estuary, on the south shore of the Strait of Magellan. . . showed essentially no change in 1-1/2 years." Hayes et al. predicted a life span of at least 10 years for that oil. The Yukon River Delta is perhaps the most typical example of this habitat type in our area.

The possible general effects of an oil spill on fishery resources have been summarized by Trasky et al. (1977) and can be considered as either acute or chronic in nature. They state, "acute oil spills are those that result from a **single** infusion of oil into the marine environment from an accidental spill. . . . **Chronic** oil pollution is the discharge of hydrocarbons into the marine environment either continuously or sufficiently often that the **biota** does not have time to recover between doses."

Our studies indicate, that during the open water period from breakup to freezeup, **anadromous** species comprise the bulk of fish (by percent composition) inhabiting coastal waters. Consequently, they would be among the most vulnerable to disruption from oil pollution. These species collectively dominate the subsistence fishery in our area with salmon species comprising nearly all of the commercial fishery income.

Kendel et al. (1975) speculated that **anadromous** Arctic fish populations other than salmon encountered during their studies can withstand short term and to a lesser degree long term fluctuations of the marine environment due to their **life** history patterns. His reasons were as follows:

- a. Spawning occurs in freshwater, hence mass disruption of this critical life stage is not likely to occur;
- b. Residence at sea of mature populations is limited to two to three months annually (possibly longer in our area);
- c. The distribution of species is widespread;
- d. The great variance of age classes insures that survival is not dependent on any single year class (Craig and McCarty 1975, not seen by author); and

- e. Differences in habitat preference by various life stages ensures that entire populations are not affected by disruptions in a given area.

Although little is known about the life history of anadromous forms in our area it is probable that great similarities exist between them and those anadromous populations described by Kendel. Consequently, it is not likely that acute oil spills as defined by Trasky et al. (1977) would eliminate an entire population. However, long term chronic pollution problems could have deleterious effects upon these fishery resources by disrupting any of the numerous events necessary for feeding, migration, spawning, etc.

Certain marine forms are also abundant in coastal waters during the ice free period; some showing both spatial and temporal separation throughout our study area. Herring for example, are known to spawn only in the spring immediately following ice breakup along various coastal habitats ranging from those of low susceptibility (e.g., Cape Denbigh) to those of high susceptibility (e.g., Imuruk Basin). Although herring provide the second most important source of commercial fishery income, their commercial exploitation in our area has not been fully realized as in other areas of the Bering Sea.

Major contamination of herring spawning habitats during the spring months could have catastrophic effects upon these populations depending upon recruitment from previous years. It is more likely that spawning populations along the Seward Peninsula which utilized shallow lagoons, bays and inlets would be most effected because these habitats are impacted to a greater extent by chronic pollution than exposed rocky headlands which are primarily utilized by spawning herring populations in the eastern portion of Norton Sound. An acute oil spill in either habitat type during the spring spawning period could conceivably eliminate an entire year-class of herring from the affected area.

In general, several coastal sections throughout our study region would be high risk areas based upon the criteria described by Hayes et al. (1977). Perhaps one of the most vulnerable would be the Yukon River Delta, a habitat type having the highest susceptibility rating. The Yukon River Delta is perhaps the most important ecosystem in the Norton Sound-Kotzebue Sound areas in terms of biomass of fish produced. The delta complex encompasses approximately 3,900 square kilometers and is subject to potential impact from oil exploration and development. Contamination of this area could have catastrophic effects upon fishery resources common to the region. Among these resources are the commercially important salmon species as well as ciscos, sheefish and other whitefish, all of which are major subsistence fishery items to local residents. It is also likely that heavy pollution of this area could be spread to other areas of Norton Sound by Bering Sea currents.

At least two seasons of work in the delta area are needed. Studies should be designed to determine the seasonal distribution and movement by species into and within the study area, growth and relative maturity of major species and trophic relationships.

A second area which is nearly certain to be impacted from petroleum related activities and one which exists as having variable susceptibility ratings is the Port Clarence/Grantley Harbor complex. Port Clarence is the only deep water harbor north of Dutch Harbor. Consequently, it could be an important staging or refueling stop for large vessels associated with oil activities, particularly if leasing of the Norton Sound area occurs. Potential impact also exists from activities even further north in the Arctic Ocean. Only a single season of work has been conducted in this area during our investigations. Our studies merely documented various species which occur and also that nearly 100% of all fish harvested locally are utilized for subsistence needs. Such species include salmon, Arctic char, ciscos and other whitefish species, flounder, saffron cod, smelts and herring. Of the three major areas in the Port Clarence region, Imuruk Basin possesses the highest susceptibility to spills based upon Hayes' criteria. It was in this area that the largest number of juvenile herring (Ages 0, I and II) were found. Imuruk Basin is probably an important overwintering and/or rearing area for other species as well.

That a major oil spill in Port Clarence or Grantley Harbor could impact Imuruk Basin was observed during our studies in 1977. A sinking gillnet was deployed on September 30 at the mouth of the Tuksuk channel in Grantley Harbor. Within one to two hours the net was recovered approximately three to four kilometers up the Tuksuk Channel near Imuruk Basin. It had been carried by deep currents flowing up the channel from Grantley Harbor toward Imuruk Basin; currents which flowed in the opposite direction of outflowing surface water.

Studies should be conducted in the Port Clarence/Grantley Harbor complex to determine trophic relationships for major fish species, spawning and rearing areas, and also to examine age dependent movement of populations and seasonal growth characteristics.

Virtually nothing is known concerning the range, distribution, relative abundance, age structures or relative maturity of fishery resources during the winter months (that period from freezeup to breakup). This period encompasses roughly seven months of the year, usually from the end of October through early June. The lack of knowledge makes it difficult to even conjecture the degree of vulnerability for that time period.

Age, sex, size and maturity information as well as abundance and distribution of major species in winter months should be obtained. It is reasonable to assume that seasonal variation occurs especially in the case of anadromous species. Approximately 26% (10 species) of the species in the coastal waters of Norton Sound during the ice free period (1976-77 OCS studies) are anadromous, 24% freshwater, and 50% marine forms. Undoubtedly, marked shifts in abundance and distribution occur during the winter months. Many marine and/or anadromous forms could be greatly affected by petroleum pollution during the winter months and at critical times of their life cycle. This is especially applicable for some herring populations where juveniles apparently overwinter in several lagoon areas along the Seward Peninsula.

Winter sampling would be difficult due to weather conditions in the study area for that period of the year. Consequently, such studies should be conducted for at least two years, working selected areas each year. Winter weather conditions would create logistical problems not encountered during the ice free period, consequently, large coastal sections (e.g., St. Michaels to Nome) could not be sampled in a single winter. Important areas to be sampled would include Shismaref Inlet, Port Clarence, Golovin Bay and south and eastern Norton Sound (St. Michael to Cape Denbigh). South and eastern Norton Sound could be sampled in one winter. Shismaref Inlet and the Port Clarence area could be sampled in a second year, possibly, along with Golovin Bay.

CONCLUSIONS

1. Subsistence utilization of fishery resources depends to a great extent upon seasonal availability although about seven families of fish are used by almost all villagers to some degree: Clupeidae, Osmeridae, Gadidae, Pleuronectidae, Salmonidae, Coregonidae and Thymallidae.
2. Herring use as a subsistence item is greater in Norton Sound than in Kotzebue Sound. However, subsistence use throughout the study area is markedly low in comparison to the Yukon-Kuskokwim region. Use is influenced by abundance of herring, village location, marine and large terrestrial mammal harvests as well as employment opportunities.
3. Spawning herring populations north of the Yukon River are relatively small in comparison to those in the southern Bering Sea (Bristol Bay). The relative abundance of herring throughout the study area has decreased from historic levels.
4. Timing of herring spawning throughout the study area is associated with spring breakup (ice recession) of the Bering Sea. Spawning generally commences in southern Norton Sound in early June and occurs progressively later to the north; as late as August in parts of Kotzebue Sound.
5. Some herring spawning occurred prior to ice breakup in the Port Clarence area in 1977 based on the presence of young-of-the-year herring and post spawning adults immediately at ice breakup.
6. There are basically two habitat types associated with herring spawning; exposed rocky headlands in the Norton Sound area and shallow embayments and lagoons on the Seward Peninsula.
7. Sexual maturity of herring in our area begins mainly in the third year, also in the fourth and rarely in the fifth year. Sexual maturity may occur later in herring populations further north.

8. Independent stocks of herring occur north of Norton Sound. These herring differ significantly in size and behavioral characteristics from those in Norton Sound and southward, into the southern Bering Sea. Herrings north of Norton Sound have a smaller mean size-at-age and spawn, overwinter and rear in shallow lagoons and embayments; as such are considered euryhaline in salinity tolerance.
9. Pacific herring are widely distributed throughout coastal and offshore waters of Norton Sound in the fall and early winter.
10. Juvenile pink and chum salmon are present in the nearshore coastal waters of Norton Sound from ice breakup through about the first week of July. Both species exhibit similar growth rates during this period.
11. There appears to be no stock separation by river bank of smelting chum salmon in the Yukon River.
12. Arctic char populations throughout coastal marine waters of Norton Sound are likely a mixture of stocks from various rivers; the degree of mixing is not known.
13. The relative abundance of Arctic char in the coastal waters of Norton Sound is greatest in the spring and early summer months. Juvenile Arctic char (less than 200 mm) are not present in coastal marine waters in significant numbers approximately one month after ice breakup.
14. The frequency of occurrence and abundance of finfish species is greatest in nearshore surface waters. However, both vary spatially and temporally throughout the study area.
15. Although species diversity of finfish is similar among all areas in nearshore waters, abundance appears to be lowest in the southern and eastern portion of Norton Sound as opposed to either Golovin Bay or the Port Clarence area.
16. At least 90% of the anadromous species, 75% freshwater species and 30% marine species occurring in nearshore waters are utilized for subsistence purpose. Approximately 60% of the anadromous species, 10% freshwater species and, at present, 5% of marine species are harvested commercially by domestic fisheries.
17. The distribution of larval finfish is widespread throughout nearshore and offshore surface waters of Norton Sound during spring and early summer. This is particularly true of larval boreal smelt in nearshore waters and larval saffron cod in offshore surface waters.
18. Further studies are needed in the Norton Sound area to ensure proper planning and development of petroleum related activities.

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APPENDIX X TABLES

Table 1. Northern Bering Sea fall herring production, 1916-1941.

Year	Location	Number of Processors	Scotch Cured		Hard Salted Barrels	Remarks
			Barrels	Half Barrels		
1916	Golovin Teller	4 1	559* 9*			*Norwegian pack as opposed to Scotch style.
1917	^{1/} Golovin Teller	5 1	1,275* 300*			^{1/} Introduction of Scotch method of curing by U.S. Bureau of Fisheries.
1918	Golovin Council	11 1	5,169* 167*	^{2/}		
1919	Golovin	6	2,555*	^{3/}		^{2/} Includes 500 bbls. of Scotch style.
1920	Golovin	4	331			
1921	Golovin St. Michael	1 1	562 60			^{3/} Includes 900 bbls. of Scotch style.
1922	Golovin	2	500			
1923	Golovin	1	352			
1924	Golovin	1	750			
1925	Golovin	1	200			
1926	Golovin	1	620			
1927	Golovin	1	490	100		
1928	Golovin	1	850 ^{4/}	370		^{4/} Includes 435 bbls. of bloater stock.
1929	Golovin	1	200* ^{5/}	887*		
1930	Golovin	3	1,637 ^{6/}	1,614		^{5/} Plus an additional 432 half tierces of bloater stock,
1931	Golovin	2	219 ^{7/}	180		
1932	Golovin	3	3,533 ^{8/}	905		^{6/} Includes 26 tierces and 500 half tierces; plus an additional 62 tierces of roused herring.
1933	Golovin	2	8 ^{9/}	75		
1934	Golovin	1		42	100	
1935	Golovin	1		57	96	^{7/} Plus an additional 238 half tierces of bloated stock.
1936	No commercial operations reported					
1937						^{8/} Plus an additional 31 tons of bloater stock.
1938	Golovin	1		35	62	
1939	Golovin	1		27	30	^{9/} Plus an additional 25 tons of bloater stock.
1940	Golovin	1	16	22	85	
1941	Golovin	1			30	

Summary: ^{10/} 3,201,625 lbs. Scotch cured (52.0%)
2,319,375 lbs. Norwegian cured (37.7%)
488,750 lbs. Bloater stock (7.9%)
100,750 lbs. Hard salted (1.6%)
49,600 lbs. Roused herring (0.8%)
6,160,100 lbs. All products (1916-1941)

^{10/} One full barrel contains 250 pounds of herring. Three size grades were packed: large herring (No. 1) measuring 30-33 cm total length were packed 450 to a barrel; No. 2 herring went 550 to a barrel; No. 3 herring went 650-700 to a barrel (Wigutsoff and Carlson, 1950). One tierce equals 800 pounds (Pacific Fisherman, 1931). A total of 98.6% of the total production from 1916-1941 was processed in Golovin.

Table 2. Commercial harvest of spring herring for roe extraction in Norton Sound, 1964-1977.

Year ^{1/}	Production Location	Herring		Sac Roe (Pounds)	Percent Recovery	Remarks
		Pounds	Metric Tons			
1964	Unalakleet	40,000	18.1	2,520	6.3	Roe product poor due to poor handling methods.
1965		NO DOMESTIC COMMERCIAL OPERATIONS				
1966	Golovin	23,700	10.8			First foreign effort on herring occurred in Norton Sound in 1968.
1967-68		NO DOMESTIC COMMERCIAL OPERATIONS				
1969	Unalakleet	≈4,000	≈1.8	< 350	≈8.7	Heavy foreign effort. Two Japanese vessels apprehended near St. Michael.
1970	Unalakleet	16,000	7.3	1,345	8.4	
1971	Unalakleet	39,000	17.7	3,180	8.2	
1972	Unalakleet	33,706 ^{2/}	15.3	8,734	25.9 ^{3/}	
1973	Unalakleet	71,264 ,	32.3	2,160	3.0	
1974	Unalakleet	5,264	2.4	0	0	Roe loss due to herring spoilage in the round and poor quality of roe.
1975		NO DOMESTIC COMMERCIAL OPERATIONS				
1976	St. Michael	17,000	7.7	?	?	
1977 ^{4/}	Unalakleet	20,896	9.5	1,254	6.5	Herring fishing closed to all foreign nations by Secretary of Commerce.
Total		270,830	122.8			

^{1/} Approximately six million pounds of fall herring were commercially processed in Norton Sound from 1916-1941.

^{2/} Approximately 1,200 pounds of this amount was taken in Nome.

^{3/} The value of this figure suggests that female herring only may have been reported.

^{4/} First commercial harvest of roe on kelp occurred; 743 pounds were taken June 25 at Cape Denbigh.

Table 3 . Herring production of Japan and USSR in the eastern Bering Sea, 1964-1977 ^{1/}

Year ^{2/} (July - June)	Trawl Fishery USSR ^{3/} Japan		Japanese Gillnet Fishery	Total
1964-65		1,362		--
1965-66		3,717		-
1966-67		2,831		-
1967-68	9,800	9,486	818	20,104
1968-69	75,379	50,857	1,949	128,185
1969-70	92,228	23,901	1,585	117,714
1970-71	60,126	24,236	4,603	88,965
1971-72	67,547	13,143	472	81,162
1972-73	39,999	346	1,878	42,223
1973-74	16,910	219	3,337	20,366
1974-75	15,039	2,663	736	18,438
1975-76	9,518	2,728 ^{4/}	2,668 ^{4/}	14,914
1976-77	18,104	1,766	^{5/}	19,870

^{1/} All harvests expressed in metric tons. Source of Japanese catches from INPFC documents while USSR catches furnished under provisions of US-USSR bilateral agreements.

^{2/} Trawl fishery normally occurs from Nov to Apr while the gillnet fishery lasted from April to June.

^{3/} The USSR trawl fishery began in 1961, but harvest data was not available until 1967.

^{4/} Preliminary.

^{5/} Japanese gillnet fishery closed.

Table 4. Japanese **gillnet** herring catches in Norton Sound (north of 63° N. latitude and east of 167° W. longitude) 1968-77.

Year	Gillnet Catch 1/	Remarks
1968	0.119	First foreign effort on herring in Norton Sound.
1969	1.270	Peak catch with large effort (about 40 ships). Two vessels apprehended.
1970	0.063	
1971	0.638	
1972	0.014	
1973	0.035	
1974	0.693	
1975	0	
1976		Data unavailable at time of writing this report.
1977		Herring fishery closed to foreign nations.
Total	2.832	Excludes 1976 catches.

1_/ Catch expressed in thousands of metric tons. All catches were made in the second quarter April through June.

Table 5 . Census areas from the Yukon River Delta to Point Hope, 1976-77.

Census Areas				Linear Shoreline Distance		Census Area ^{1/}
Area	No.	North* Latitude	West* Longitude	Miles	km	Mid Point (km)
Black River-North Mouth Yukon River	31	63°08'30"	164°33'50"	120.0	193.0	96.5
North Mouth Yukon River-Canal Point	32	63°12'30"	162°47'20"	40.9	65.8	32.9
Canal Point-Cape Stebbins	33	63°28'40"	162°18'00"	12.3	19.8	9.9
Stuart Island	34	63°33'05"	162°20'30"	41.9	67.5	Perimeter
Cape Stebbins-St. Michael	35	63°30'50"	162°08'00"	15.5	25.0	12.5
St. Michael-Klikitarik	36	63°21'05"	161°57'05"	18.3	29.5	14.8
Klikitarik-Unalakleet River	37	63°31'30"	161°01'00"	40.4	65.0	32.5
Unalakleet River-Cape Denbigh	38	64°13'45"	160°58'15"	52.8	85.0	42.5
Cape Denbigh-Bald Head	39	64°38'40"	160°47'30"	80.8	130.0	65.0
Bald Head-Cape Darby	40	64°41'10"	162°08'10"	70.5	113.5	56.8
Cape Darby-South Spit	41	64°36'10"	163°06'00"	55.9	90.0	45.0
South Spit-Topkok Head	42	64°30'20"	163°20'35"	36.0	58.0	29.0
Topkok Head-Point Spencer	43	64°30'00"	165°24'20"	94.4	152.0	76.0
Point Spencer-Cape Prince of Wales	44	65°18'40"	166°17'54"	124.3	200.0	100.0
Cape Prince of Wales-Cape Espenberg	45	66°15'50"	166°04'00"	149.1	240.0	120.0
Cape Espenberg-Kiwalik	46	66°07'10"	163°51'00"	127.4	205.0	102.5
Kiwalik-Point Garnet (Choris Pen.)	47	66°11'35"	160°59'30"	90.1	145.0	72.5
Point Garnet - Selawik Lake entrance	48	66°56'15"	162°31'20"	119.6	192.5	96.3
Selawik Lake entrance-Sheshalik	49	67°00'40"	161°38'50"	111.8	180.0	90.0
Sheshalik-Point Hope	50	67°43'25"	164°36'00"	141.1	240.0	120.0
Total	31-50			1,551.1	2,496.6	

^{1/} Linear shoreline distance on either side of census area mid point,

* Latitude and Longitude of mid point of census area.

Table 6 . Characteristics and indices used to determine the relative maturity of Pacific herring.

Index	Key Characteristics
I	Virgin herring. Gonads very small , threadlike, 23 mm broad. Ovaries WINE red. Testes whitish or grey-brown .
II	Virgin herring with small sexual organs. The height of ovaries and testes about 3-8 mm. Eggs not visible to naked eye but can be seen with magnifying glass. Ovaries a bright red color; testes a reddi sh-grey color.
III	Gonads occupying about half of the ventral cavity. Breadth of sexual organs between 1 and 2 cm. Eggs small but can be distinguished with the naked eye. Ovaries orange; testes reddish-grey or greyish .
IV	Gonads almost as long as body cavity. Eggs larger varying in size, opaque. Ovaries orange or pale yellow; testes whitish.
V	Gonads fill body cavity. Eggs large, round; some transparent. Ovaries yellowish, testes milkwhite . Eggs and sperm do not flow, but sperm can be extruded by pressure.
VI	Ripe gonads; eggs transparent; testes white. Eggs and sperm flow freely.
VII	Spent herring. Gonads baggy and bloodshot. Ovaries empty or containing only a few residual eggs. Testes may contain remains of sperm.
VIII	Recovering spent. Ovaries and testes firm and larger than virgin herring in Stage II. Eggs not visible to naked eye . Walls of gonads striated; blood vessels prominent. Gonads wine red color, This Stage passes into Stage III .

Table 7 . Relative size and abundance of herring schools from aerial surveys conducted from Stuart Island to Point Garnet (Eschscholtz Bay}, from June 9 through October 28, 1977.

Area Surveyed ^{1/}	Date	Survey Rating Index ^{2/}	Fish School Size ^{3/}				Total	Spawn Observations		Remarks
			small	medium	large	unc.		No. Sp.	Area (m2)	
Stuart Island (344 - 34d)	5/15 6/22	F P					none none			
Cape Stebbins to Unalakleet (35, 36, 37)	6/9 6/15 6/17 6/22*	G-E G-F G-F F-P					none none none 1			
Total			1							
Unalakleet to Shaktoolik River (Me. 160)	6/9 6/14 6/15* 6/17 6/22 6/25 7/21	E-G G G-F G P F F		23			none none 23 none none none none			3 small schools near Egavik; remainder between Shaktoolik & Shaktoolik River. Adjacent to Beason Slough.
Total			33				23	1		
Shaktoolik River to Island Point (Cape Denbigh) (38c, 39a, 39b)	6/9 6/14 6/15 6/17* 6/22 6/25 7/21	E-G G G-F G P F G	20	2			none 32 29 57 3 3 none			2 small schools south of Cape Denbigh; remainder between Cape Denbigh & Pt. Dexter. 5 small and 1 med school near Pt. Dexter, remainder between C. Denbigh & Shaktoolik R. 2 large & 1 med school just south of Cape Denbigh; remainder between Cape Denbigh and Pt. Dexter. Schools all on N. side of Cape Denbigh. Schools all on m. side of Cape Denbigh.
Total			25	23	7		118			
Kuiuukrulik River to Kwik R. (Bald Head) (39d, 40a)	5/14 5/15* 6/17 5/25* 7/21	G F E F G	5	1			none 6 2 7 none			Schools at Bald Head. Schools at Bald Head. Schools between Bald Head & Kuiuukrulik R.
Total			11	4			.15			
Kwik River w Cape Darby (40b, 40c, 40d)	6/9 6/14 6/15 6/17 6/22 6/25*	E-G G F E U F					none none none none none 8			4 med schools at Elim; remainder off-shore at Moses Pt.
Cape Darby to Rocky Point (Golovin Bay) (41a, 41b, 42a)	6/14* 6/17 6/22 6/25* 7/21	G F U F G	3				3 none none 11 none			schools at Carolyn Island. One med at Rocky Pt; remainder on east side of bay between Cape Darby and Golovin
Total			7	7			14			
Rocky Point to Cape Nome (42b, 42c, 43a)	6/14* 6/17* 7/10 7/21 8/29	G F F G U	5	2			5 12 none none none			Schools near Topkok Wad. Schools from Rocky Pt. to Topkok Head. Several small schools seen (Rocky Pt. to Topkok Head) believed to be sand-lance.
Total	9/1		15	2			17			
Cape Nome to Point Spencer (43b, 43c, 43d)	6/21 6/28* 7/10 7/11* 7/21* 8/4 8/6 8/23* 10/16	F G F F G U F U			4		none 5 6 23 46 none none none none			Schools at mouth of Cripple Cr. Species unknown. Schools between Cape Wooley & Cape Douglas. Schools from Sinuk R. to Cape Douglas. Schools from Cripple Cr. to Pt. Spencer. Capelin carcass survey. Ft. Davis - Penny Q. Schools about 2 miles east of Sinuk R.
Total			30	13	11		82			

(Table Continued I

Table 7 continued. Relative abundance of herring schools from aerial surveys conducted from Stuart Island to Point Garnet (Eschscholtz Bay) from June 9 through October 28, 1977, shown by school size.

Area Surveyed ^{1/}	Date	Survey Rating Index	Fish School Size ^{2/}				Spawn Observations			Remarks	Remarks
			small	medium	large	Unc.	total	No.	Area (m2)		
Point Spencer to Wales (Port Clarence/Grantley Harbor) (44a - 44f)	6/21	U					none			Shore ice - too early.	
	6/28	P					none				
	7/10	F					none				
	7/11	F	1				1			School near Lost River (No survey Pt. Clarence).	
	7/21*	G	1s	6.	z		25			Two small & 1 med inside Pt. Clarence & Pt. Spencer: 10 small & 1 med. from Brevig to Grantley Harbor; remainder in Grantley Harbor @ Teller & Tuksuk Channel. Believed to be herring.	
	8/6	G					none				
	8/13	P					none				
	8/20	U					none			Survey of Lost R. area only. Poor water visibility - turbid.	
	8/23	F					none				
	9/9	G					none				
	10/16	U					none				
Total			19	0	2						
Wales to Shishmaref (45a and 45c)	7/11*	E	16	16	11		43			Schools migrating north; believed herring.	
	8/6*	P	9	3			12			Schools believed to be herring.	
	8/13	P					none				
	8/20*	U	1	1			2			Turbid water - species unknown.	
	9/9	F					none				
	10/8	U					none			Turbid water & high winds.	
	10/26	U					none			Blowing snow - survey aborted.	
	10/28	U					none			Blowing snow - survey aborted.	
			25	20	11		57				
	Total										
Shishmaref to Cape Epsenberg (45e and 45h)	7/11*	E	15	17	16		48			Schools all along coastline. Many in lagoon entrance to Shishmaref Inlet and Compack Inlet. Fish believed to be herring.	
	7/13	E	10	a	4		22			Surveyed only Shishmaref to Kivido.	
	8/6	ii					none				
	8/20*	U	a	z			none			Turbid water - species unknown.	
	9/9	F					a				
	10/8	U					none			Turbid water and high winds.	
	10/26	U					none			Blowing snow - survey aborted.	
	10/28	U					none			Blowing snow - survey aborted.	
			31	27	20		8				
	Total										
Cape Epsenberg to Good Hope (River) (46a)	7/11	F-P					none			Turbid water and shallow. Poor surveyable area.	
	9/9	U					none				
Good Hope River to Kivalik (46b, 46c, 46d, 46e)	7/11	G					none				
	7/20*	E	9	8	2		19			Schools from Rex Pt. to Ninemile Pt. Schools & possible spawn just east of Cape Deceit & Deering.	
	8/13	U		1	1		3	1(?)			
	9/20*	P	17	1			18	1(?)		One med 6 l small just east of Clifford Pt. 16 small about 2 miles east of Ninemile Pt. Possible spawn at Ninemile Pt. Fish believed to be herring.	
			26	10	3	1	40	2(?)			
Total											
Kivalik to Point Garnet on Choris Peninsula (47a, 47b, 47c)	7/11	G					none			Partial survey to Buckland.	
	7/20*	F	1	2	1		4			One med & 1 large school in Kivalik; One small & 1 med school on east side of Choris 'm. 36 Beluga moving west on south side of Baldwin Pen.	
	8/20	P					none			Partial survey to Buckland.	
							4				
Total											
TOTAL 1977 COUNT			286	138	55	1	480	1			

^{1/} Number in parenthesis indicate census areas.

^{2/} Survey rating index: E - excellent; G - good; F - fair; P - poor; U - unacceptable.

^{3/} Classification to fish schools: small - surface area estimate less than 50 m² (500 ft²); medium - surface area estimate 50 - 450 m² (500 - 5,000 ft²); large - surface area estimate greater than 450 m² (5,000 ft²); unclassified - surface area estimate not made.

*Relative Abundance Index (RAI): Days on which survey counts were used for determining the relative abundance of fish schools in a given area of the coastline. If sightings in a given area were within 10 - 15 days of each other, they were considered to be the same fish schools. The dates used to arrive at the RAI for a given area do not necessarily coincide with peak spawning.

Table 8. List of fish species collected in nearshore coastal waters of Norton Sound, 1976-77.

Species	Common Name	Species	Common Name
<u>Clupea harengus pallasii</u>	Pacific herring	<u>Pallasina barbata alix</u>	Tukenose poacher
		<u>Ocella dodecaedria</u>	Bering poacher
		<u>Agonus acipenserinus</u>	Sturgeon poacher
<u>Oncorhynchus keta</u>	Chum salmon		
<u>Oncorhynchus gorbuscha</u>	Pink salmon		
<u>Oncorhynchus kisutch</u>	Coho salmon		
<u>Oncorhynchus tshawytscha</u>	King salmon		
<u>Oncorhynchus nerka</u>	Sockeye salmon		
<u>Salvelinus alpinus</u>	Arctic char		
<u>Stenodus leucichthys</u>	Inconnu (sheefish)		
<u>Coregonus lauretta</u>	Bering cisco		
<u>Coregonus sardinella</u>	Least cisco		
<u>Coregonus pidschian</u>	Humpback whitefish		
<u>Coregonus nasus</u>	Broad whitefish		
<u>Prosopium cylindraceus</u>	Roundwhitefish		
<u>Osmerus eperlanus (mordax dentex)</u>	Boreal (American, toothed) smelt		
<u>Mallothus villosus</u>	Capelin		
<u>Hypomesus olidus</u>	Pond smelt		
<u>Anchoa hepsetus</u>	Sand lance		
<u>Eleginus gracilis</u>	Saffron cod		
<u>Lota lota leptura</u>	Burbot		
<u>Hexagrammus lagocephalus</u>	Rock greenling (terpug)		
<u>Hexagrammus stelleri</u>	Whitespotted greenling		
<u>Liparis rutteri</u>	Ringtail snailfish		

Table 9. Fish species composition for selected areas in the coastal waters of Norton Sound, 1976-77.

			AREA CAPTURED											
CLASSIFICATION 1/	COMMON NAME	SCIENTIFIC NAME	A	C	D	E	F	G	H	I	J	K	L	M
CODE	CAT	ION 1/	76 77	76 77	76 77	76 77	76 77	76 77	76 77	76 77	76 77	76 77	76 77	76 77
PS	A	Pink Salmon	<u>Oncorhynchus gorbuscha</u>	XX	X	X X	X	X	X	XXX	X X	X		
CS	A	Chum Salmon	<u>Oncorhynchus keta</u>	XX	X X	X X	X X	X	X X X	X X	X X	X X		
SS	A	Coho Salmon	<u>Oncorhynchus kisutch</u>	XX	X	X X	X	X	X X	X X	X X	X X		
KS	A	King Salmon	<u>Oncorhynchus tshawytscha</u>	X	X	X					X X	X X		
RS	A	Sockeye Salmon	<u>Oncorhynchus nerka</u>							XX				
OH	F	Humpback whitefish	<u>Coregonus pidschian</u>	X X	XX	XX	X X	X	X X	X X	X X	X X		
BW	F	Broad whitefish	<u>Coregonus nasus</u>	X X	X	X X	X	X	XXX	X	XX	XX		
RH	F	Round whitefish	<u>Prosopium cylindraceus</u>		X X	X X	X		X	X	X	X		
BC	A	Bering clisco	<u>Coregonus lauretta</u>	XX	XX	X X	X X	X	X X X	X	XX	XX		
LC	A	Least clisco	<u>Coregonus sardinella</u>	X X	XX	XX	X X	X	XXX	X	X	X		
SI	M	Starry flounder	<u>Platichthys stellatus</u>	X X	X X	X X	X X	X X	X X X	X	XX	XX		
AF	M	Arctic flounder	<u>Lopsetta glacialis</u>	XX	X X	X X	X	X	XX		X X	X X		
RF	M	Flock flounder	<u>Lopsetta bilineata</u>						X					
AP	M	Alaska plaice	<u>Pleuronectes quadrituberculatus</u>	X X	X	X X			X	X X	X			
YS	M	Yellowfin sole (muddab)	<u>Limanda aspera</u>	XX	XX	XX	X		X					
LD	M	Longhead dab	<u>Limanda proboscidea</u>		X	X								
IP	M	Tubenose poacher	<u>Pallasina barbata</u>	X X	X X	XX		X	X X				X	
SP	M	Sturgeon poacher	<u>Acipenseridae</u>	X			X							
LIP	M	Bering poacher	<u>Ocella dodecaedria</u>	XX	X	X X	X							
MI	M	Capelin	<u>Mallotus villosus</u>	X		X			X					
PI	M	Pacific herring	<u>Clupea harengus pallasi</u>	XX	XX	X X	XX	X	X X X			X X		
OS	A	Boreal smelt (American, toothed)	<u>Osmerus eperlanus (mordax dentex)</u>	XX	XX	XX	X X	X	XXX	X	X X	X X		
OO	A	Pond smelt	<u>Hypomesus olidus</u>	X	X	XX		X	XXX			X		
SL	M	Sand lance	<u>Ammodytes hexapterus</u>	XX	X		X	X	XX					
S3	F	Threespine stickleback	<u>Gasterosteus aculeatus</u>	X					X X X					
S9	F	Ninespine stickleback	<u>Pungitius pungitius</u>	XX	X	X	XX	X	X	X X X	X	X		
RG	M	Rock greenling (terpug)	<u>Hexagrammus lagocephalus</u>	X	X	X X	XX		X X					
WG	M	White-spotted greenling	<u>Hexagrammus stelleri</u>	X X	X	X								
AC	A	Arctic char	<u>Salvelinus alpinus</u>	XX	X X	X X	XX	X	X X X	X	X X	X X		
SC	M	Saffron cod	<u>Eleginus gracilis</u>	XX	X X	X X	XX	X	X X X	X	X X	X X		
LR	M	Ringtail snailfish	<u>Liparis rutteri</u>											
SH	F	Sheefish	<u>Stenodus leucichthys</u>											
NP	F	Northern pike	<u>Esox lucius</u>											
NS	F	Northern sucker (longnose)	<u>Catostomus catostomus</u>											
LL	F	Lurbot	<u>Lota lota leptura</u>											
PR	M	Pricklebacks 2/	<u>Stichaeidae 2/</u>		X X	X	XX	X	X	X X X		X X		
CT	M	Sculpins	<u>Cottidae</u>	X X	X X	X	XX	X	X	X X X		X X		
WF	M	Bering wolffish	<u>Anarhichas orientalis</u>	X										
Total number species (less cottidae)			26 22	24 16	18 21	19 13	17 2	15	12 22 18	16 13	15 13			

AREA IDENTIFICATION:

A Golovin Bay
C Cape Denbigh - Egavik
C Egavik - Tolstoi Point

O Tolstoi Point - Cape Stebbins

E Fish River mouth
F Rocky Point - Bluff
G Grantley Harbor

O Port Clarence

I Inuvik Basin
J Flat Island (south mouth Yukon River)
AJF Anuk River (10 km upstream from Flat Island).
ONL Unalakleet River lagoon

1/ A - anadromous; f - freshwater; M - marine.

2/ Includes two species: Lumpenus sagitta (snake prickletback) and Acantholumpenus mackayi (pighead prickletback).

3/ Juvenile Coregonidae were also captured.

Table 11. Species diversification by area of fin-fish captured in the coastal water's of Norton Sound from the Yukon River Delta to Port Clarence in 1976 and 1977 (OCS/RU 19).

	Golovin Bay Area			South and Eastern Norton Sound Area				Port Clarence Area				FI	URL	All Areas Total
	A	F	AF	B	C	D	BCD	G	H	I	GHI			
Freshwater	4	2	4	3	4	3	4	5	3	7	7	7	4	9 (23.7%)
Anadromous	9	6	9	9	9	7	9	9	8	8	9	8	8	10 (26.3%)
Marine	14	9	16	14	15	11	17	8	11	3	11	1	5	19 (50.0%)
Total	27	17	29	26	28	21	30	22	22	18	27	16	17	38
Cottidae	x ^{1/}	x	x	x	x	x	x	x	x	x	x		x	

^{1/} Indicates that this family of fish (Cottidae) was also represented in an area.

A - Golovin Bay

B - Cape Denbigh to Egavik

C - Egavik to Tolstoi Point

D - Tolstoi Point to Cape Stebbins

F - Rocky Point to Bluff

G - Grantley Harbor

H - Port Clarence

I - Imuruk Basin

FI - Flat Island (South Mouth Yukon River - Delta Area)

URL - Unalakleet River Lagoon

Table 12. Total catch, effort and catch per effort of Pacific herring by sample area in Norton Sound from ice breakup to freezeup, 1977.

	Golovin Bay (Area A)		Port Clarence (Area H)		Grantley Harbor (Area G)		Imuruk Basin (Area I)		Remainder of Norton Sound (Areas B, C, D, F)	
Catch	#	%	#	%	#	%	#	%	#	%
Adult herring	244	80	636	94	1,015	95		44	71	89
Juvenile herring	62	20	39	6		5	11	56	10	11
Total	306	-	675	-	1,015	-	225	-	81	-
*EFFORT ^{1/}										
Gillnets	252.6		66.2		52.2		18.9		119.5	
Beach Seines	68		26		26		11		24	
*CATCH/EFFORT ^{2/}										
Gillnets	0.9		7.3		19.5		3.5		0.6	
Beach seines	0.9		7.4		1.7		14.5		0.3	

* Includes both adults and juveniles.

^{1/} Effort is expressed as number of **gillnet** hours and number of good beach seine sets.

^{2/} Catch per effort is expressed as number of herring per gillnet hours and number of herring per good beach seine set.

Table 13. **Total** catch of adult and juvenile herring by gear type captured in the Port Clarence area from June through October, 1977.

Sex	Beach Seine		Floating Gillnet		Sinking Gillnet		Total	
	#	%	#	%	#	%	#	%
Adults (♂ + ♀)	192	11	992	57	566	32	1,750	100
Juveniles	205	95	3	1	7	4	215	100
Total	397	20	995	51	573	29	1,965	100
Adults (♂ + ♀)	192	48	992	99	566	99	1,750	89
Juveniles	205	52	3	1	7	1	215	11
Total	397	100	995	100	573	100	1,965	100

Table 14. Percent composition by area and gear type of herring captured in Port Clarence, Grantley Harbor and Imuruk Basin from June through October, 1977.

gear type	Port Clarence		Grantley Harbor		Imuruk Basin		Total		
	#	%	#	%	#	%	#	%	
Juvenile Herring	Beach seine	37	18	95	22	123	60	205	100
	Floating gillnet	0	-	1	33	2	66	3	100
	Sinking gillnet	2	29	4	57	1	14	7	100
	Total	39	18	50	23	126	59	215	100
	Beach seine	37	95	45	90	123	97	205	95
	Floating gillnet	0	-	1	2	2	2	3	1
	Sinking gillnet	2	45	4	8	1	1	7	4
	Total	39	100	50	100	126	100	215	100
Adult Herring	Beach seine	156	81	0	-	36	19	192	100
	Floating gillnet	338	34	620	63	34	3	992	100
	Sinking gillnet	142	25	395	70	29	5	566	100
	Total	636		1,015		99	6	1,750	100
	Beach seine	156	25	0	-	36	36	192	11
	Floating gillnet	338	53	620	61	34	34	992	57
	Sinking gillnet	142	22	395	39	29	30	566	32
	Total	636	100	1,015	100	99	100	1,750	100

Table 15. Percent composition by gear type and sex of herring captured in the Port Clarence area from June through October, 1977.

Sex	<u>Beach Seine</u>		<u>Floating Gillnet</u>		<u>Sinking Gillnet</u>		#	<u>Total</u>	
	<u>#</u>	<u>%</u>	<u>#</u>		<u>#</u>	<u>%</u>			<u>%</u>
Male	52	10	248	46	239	44	539	100	
Female	62	12	199	39	253	49	514	100	
Total	114	11	447	42	492	47	1,053	100	
Male	52	46	248	55	239	49	539	51	
Female	62	54	199	45	253	51	514	49	
Total	114	100	447	100	492	100	1,053	100	

Table 16. Relative maturity by age class of herring captured in the Port Clarence area from ice breakup (late June) through July 21, 1977.

Age	Immature Gonad 1	n	Mature 1/ Gonad 11	n	Mature Gonads III-VIII	n	Total n
111	32.1%	9	21.4%	6	46.5%	13	28
IV	0		5.9	1	94.2	16	17
V	1.0	5	4.2	21	94.8	479	505
VI	0		10.3	3	89.5	26	29
VII	0		7.1	2	92.9	26	28
VIII	0		0		100.0	14	14
I X+	0	<u>14</u>	6.4	<u>3</u> 36	93.6	<u>44</u> 618	<u>47</u> 668

1/ Possible mature in older age classes since gonad VIII and II are very similar.

Table 17. Relative maturity by age class of herring captured in the Port Clarence area from July 22 through September 6, 1977.

Age	Immature Gonad I		Possible Mature 1/ Gonad II		Mature Gonads III-VIII		Total n
	I	n	II	n		n	
III	0%		0%		100.0%	21	21
IV	0		0		100.0	3	3
V	0		0		100.0	15	15
VI	0		0		100.0	1	1
VII	0		0		100.0	2	2
VIII	0		0		100.0	1	1
IX+	0		0		100.0	<u>10</u> 53	<u>10</u> 53

1/ Possible mature in older age classes since gonad VIII and II are very similar.

Table 18. Relative maturity by age class of herring captured in the Port Clarence area from September 7 through October 21, 1977.

Age	Immature		Possible Mature 1/		Mature		Total
	Gonad I	n	Gonad II	n	Gonads III-VIII	n	
0	100%	13	0%		0%		13
I	80	4	20	1	0		5
II	0		100	2	0		2
III	4.0	1	24.0	6	72.0	18	25
IV	0		0		100.0	10	10
V	0		0		100.0	30	30
VI	0		0		100.0	a	8
VII	0		0		100.0	7	7
VIII	0		0		100.0	4	4
IX+	0		0		100.0	9	9
		<u>18</u>		<u>9</u>		<u>86</u>	<u>113</u>

1/ Possible mature in older age classes since good gonad VIII and II are very similar.

Table 19. Percent composition by gear type and sex of herring captured in **Golovin** Bay from June through October, 1977.

Sex	<u>Beach Seine</u>		<u>Floating Gillnet</u>		<u>Sinking Gillnet</u>		<u>Total</u>	
	#	%	#	%	#	%	#	%
Male	0	-	103	72	40	28	143	100
Female	1	1	67	78	18	21	86	100
Juvenile	62	100	0		0		62	100
Total	63	22	170	58	58	20	291	100
Male	0	-	103	61	40	69	143	49
Female	1	2	67	39	18	31	86	30
Juvenile	62	98	0		0		62	21
Total	63	100	170	100	58	100	291	100

Table 20. Percent fullness of herring stomachs examined during the spring of 1976 from selected areas along the western Alaska coast.

Stomach Percent Full	Togiak Area		Yukon-Kuskokwim Delta Area		Norton Sound Area		Total	
	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total
Empty	8	40	30	64	16	20	54	37.0
Trace	7	35	12	26	34	43	53	36.3
25%	2	10	5	10	11	14	18	12.3
50%	0	0	0	0	9	11	9	6.2
75%	1	5	0	0	3	4	4	2.7
100%	0	0	0	0	5	6	5	3.4
Distended	2	10	0	0	1	1	3	2.1
Sample Size	20		47		79		146	

Table 21. Percent frequency of occurrence and number of food items found in herring stomachs examined from selected areas along the western Alaska coast in the spring, 1976.

Item	Togiak Area		Yukon-Kuskokwim Delta Area		Norton Sound Area	
	Percent Frequency Occurrence	Percent Food	Percent Frequency Occurrence	Percent Food	Percent Frequency Occurrence	Percent Food
Mysidacea (opposum shrimp)			25	10	8	1.8
Copepoda			75	30	67	15.1
Cladocera	33	11.1			83	18.9
Cirripedia (barnacles)	67	22.2	50	20	50	11.3
Cumacea					33	7.5
Decapoda (shrimp, crayfish, lobsters)					25	5.7
Mollusks					17	3.8
Annelida (segmented worms)					17	3.8
Platyhelminth (flatworms)	100	33.3	25	10	8	17.0
Miscellaneous	Algae Egg Case 100	33.3	Detritus Egg Egg Case 75	30	Fish Scale Detritus Egg Herring 67	15.1

Table 22. Fork lengths of juvenile pink and chum salmon captured in the nearshore waters of Golovin Bay from June 9 through July 7, 1977. ^{1/}

Date	Station	Pink Salmon mean fork length			Chum Salmon mean fork length		
		Golovin Lagoon	Eastside Outer Golovin Bay	Westside Outer Golovin Bay	Golovin Lagoon	Eastside Outer Golovin Bay	Westside Outer Golovin Bay
June 9	7	31.0			34.6		
June 11	9			31.9			35.0
	10			31.7			36.4
June 12	2		30.6			35.7	
June 14	5	32.4			36.2		
	7	36.0			37+3		
June 17	9			33.6			35.9
June 20	6	33.6			40.2		
June 22	5	38.0			40.6		
June 23	1		37.2			42.0	
	2		37.6			41.2	
June 24	9			39.4			46.5
	10			35.3			44.1
June 26	6	41.3	43.8		46.0	47.0	
July 4	10			52.4			54.0
July 6	2		55.2			60.4	
July 7	5	54.0			63.2		

^{1/} Sample sizes were 329 for pink salmon and 360 for chum salmon.

Table 23. Daily growth rates (percent) of juvenile pink and chum salmon captured in Norton Sound, 1976-77.

	28 days		62 days		
	mean length 2nd week June (breakup)	change in length	mean length 1st week July (depart nearshore waters)	change in length	mean length 1st week September (reside in offshore waters)
Pink	32 mm	22 mm (68.8% increase)	54 mm	111 mm (205.6% increase)	165 mm
Chum	35 mm	24 mm (68.6% increase)	59 mm	124 mm (210.2% increase)	183 mm
	increase in length per day		increase in length per day		
Pink	0.79 mm		1.79 mm		
Chum	0.86 mm		2.00 mm		
	Average % increase in growth per day		Average % increase in growth per day		
Pink	2.46%		3.32%		
Chum	2.45%		3.39%		
	Average % increase in growth per day from 2nd week June to 1st week Sept. (90 days)				
Pink	4.62%				
Chum	4.70%				

Table 24. Larval **finfish** captured in the nearshore waters of Norton Sound from breakup to freezeup, 1977.

Sample Area	Larval		Species	
	Boreal Smelt	Pond Smelt	Gadids	Cottids
A	2,248		39	1
B	7			
C	124			
D	6			
F	100			
G	475			
H	619			7
I	1,415	371		
Total	4,984	371	39	8

Table 25. Catch, effort and species diversification by gear type of finfish sampled in the nearshore waters of Norton Sound from May 30 through October 21, 1977.

Area	Gear ^{1/}	Number of stations	Number of sets	Effort ^{2/}		Total ^{3/} catch	CPUE ^{2/}	Larva ^{14/} fish catch	Number of species captured ^{5/}
				negative	total				
A - Golovin Bay	GNS	12	44	13.4	69.9	230	3.3	5,402	13
	GNF	12	98	22.1	182.7	879	4.8		17
	BS	12	68	0	68	14,928	219.5		22
B - Cape Denbigh to Egavik	GNS	6	12	9.1	14.1	9	7.7	7	4
	GNF	6	13	0	14.3	209			14
	BS	6	5	0	5	1,196	239.2		11
C - Egavik to Tolstoi Point	GNS	7	15	9.2	15.3	11	0.7	114	4
	GNF	7	15	0	15.0	280	18.7		16
	BS	7	8	0	8	207	25.9		16
D - Tolstoi Point to Cape Stebbins	GNS	12	19	9.0	20.5	41	2.0	6	4
	GNF	12	19	2.0	20.7	143	6.9		11
	BS	12	4	0	4	151	37.8		7
E - Fish River	BS	2	2	0	2	20	10.0		3
F - Rocky Point to Bluff	GNS	6	3	0	6.7	26	3.9	100	6
	GNF	6	7	0	12.9	70	5.4		8
	BS	6	7	0	7	44,114	6,302.0		12
G - Grantley Harbor	GNS	9	25	2.0	26.6	480	18.1	475	10
	GNF	9	24	3.9	25.6	830	32.4		18
	BS	9	26	1	26	4,431	170.4		19
H - Port Clarence	GNS	9	28	7.9	32.7	406	12.4	626	9
	GNF	9	28	2.8	33.5	545	16.3		19
	BS	9	26	1	26	3,411	131.2		20
I - Imuruk Basin	GNS	5	7	0	7.8	91	11.7	1,786	9
	GNF	5	8	0	11.1	145	13.1		12
	BS	5	11	0	11	4,888	444.4		17
Unalakleet River Lagoon	BS	1	6	0	6	149	24.8		14
TOTALS	GNS	66	153	50.6	193.6	1,294	6.7	5,402	17
	GNF	66	212	30.8	315.8	3,101	9.8		24
	BS	69	163	2	163	73,495	450.9		29

1/ Gear types: GNS - gillnet sinking (offshore), GNF - gillnet floating (onshore), BS - beach seine.

2/ Gillnet effort is expressed in hours with catch per effort in fish per net hour.

3/ Beach seine effort is expressed in number of good sets with catch per effort in fish per good set.

4/ This column does not include larval catches; they were considered as incidental and not used in calculating CPUE.

5/ Incidental catches - mesh size of beach seines was not small enough to adequately sample larval populations, therefore listed separately.

6/ Cottidae is considered as a species in this table.

Table 26. Most abundant species of finfish captured in the coastal waters of Norton Sound and Port Clarence from ice breakup to freezeup, 1977.

Area	Beach Seines ^{1/}		Gillnets ^{2/}	
	Species	CPUE	Species	CPUE
Golovin Bay	pink salmon*	67.4	Pacific herring	1.0
	sand lance	65.5	saffron cod	0.9
	chum salmon*	25.1	starry flounder	0.5
Rocky Point to Bluff	sand lance	6,267.7	chum salmon	1.8
	pink salmon*	23.6	boreal smelt	1.1
	pond smelt	3.6	Pacific herring	0.7
	starry flounder	3.6		
Cape Denbigh to Egavik	sand lance	120.0	Arctic char	3.4
	saffron cod	75.0	starry flounder	2.1
	boreal smelt	16.6	least cisco	1.3
Egavik to Tolstoi point	saffron cod	7.8	Arctic char	3.0
	boreal smelt	4.8	starry flounder	2.6
	Bering poacher	3.3	Bering cisco	1.0
Tolstoi Point to Cape Stebbins	sand lance	32.5	starry flounder	1.3
	starry flounder	3.5	Pacific herring	0.9
	boreal smelt	0.5	saffron cod	0.6
	Arctic flounder	0.5	least cisco	0.6
Port Clarence	pond smelt	97.8	Pacific herring	7.6
	sand lance	9.4	boreal smelt	3.2
	saffron cod	8.5	saffron cod	1.3
Grantley Harbor	pond smelt	147.3	Pacific herring	19.4
	saffron cod	9.7	saffron cod	1.6
	sand lance	3.9	starry flounder	0.9
Imuruk Basin	pond smelt	360.2	Pacific herring	3.5
	ni nespi ne sti ckl ebacks	28.9	saffron cod	2.5
	least cisco	14.5	Bering cisco	1.9
	Pacific herring*	11.2		
All Areas Combined	sand lance	306.9	Pacific herring	3.7
	pond smelt	74.0	saffron cod	1.0
	pink salmon*	29.6	starry flounder	0.8

^{1/} Beach seine CPUE is number of fish captured per seine set.

^{2/} Includes both floating and sinking gillnet catches. The CPUE is fish captured per net hour.

* Indicates juvenile fish.

Table 27. Most frequently occurring species of **finfish** (by percent) captured in the coastal waters of Norton Sound and Port Clarence from ice breakup to freezeup, 1977.

Area	Beach Seines		Gillnets ^{1/}	
	Species	Percent	Species	Percent
Golovin Bay	starry flounder	57	saffron cod	40
	saffron cod	41	Pacific herring	28
	ninespine sticklebacks	41	humpback whitefish	25
Rocky Point to Bluff	pink salmon*	86	saffron cod	50
	starry flounder	71	boreal smelt	40
	chum salmon*	29	Pacific herring	40
	Alaska plaice	29	chum salmon	40
	sand lance	29		
Cape Denbigh to Egavik	Bering cisco	80	least cisco	36
	boreal smelt	60	Arctic char	32
	Arctic flounder	40	Arctic flounder	32
	least cisco	40	Bering cisco	32
	humpback whitefish	40		
	starry flounder	40		
Egavik to Tolstoi Point	boreal smelt	75	starry flounder	50
	chum salmon*	50	Arctic char	43
	saffron cod	50	least cisco	20
Tolstoi Point to Cape Stebbins	boreal smelt	50	starry flounder	39
	starry flounder	50	rock greenling	21
	Arctic flounder	25	least cisco	21
	least cisco	25		
	sand lance	25		
	ninespine sticklebacks	25		
Port Clarence	saffron cod	58	Pacific herring	32
	pond smelt	54	saffron cod	30
	sand lance	38	starry flounder	27
Grantley Harbor	saffron cod	50	starry flounder	43
	pond smelt	50	saffron cod	39
	Pacific herring*	31	Pacific herring	37
	least cisco	31		
	starry flounder	31		
Imuruk Basin	pond smelt	82	Pacific herring	67
	least cisco	64	saffron cod	67
	ninespine sticklebacks	64	Bering cisco	53
All Areas Combined	starry flounder	43	saffron cod	33
	saffron cod	41	starry flounder	30
	pond smelt	37	Pacific herring	27

^{1/} Includes both floating and sinking gillnet catches.

* Indicates juvenile fish.

1976-77. The CPUE for gillnets and beach seines is fish per net hour and fish per set, respectively.

BEACH SEINES		SAMPLING PERIOD																	
AREA	SPECIES	I		II		III		IV		V		VI		VII		VIII		IX	
		76	77	76	77	76	77	76	77	76	77	76	77	76	77	76	77	76	77
A	BC average	7.2	7.2	0.3	0.3	0.6	0.1	1.0	1.0	3.8	3.8	2.4	1.4	4.8	1.0	5.9	5.9	1.0	1.0
	LC average	1.3	1.3	1.9	1.9	0.1	0.6	11.8	11.8	23.2	23.2	0.4	40.9	0.8	3.4	3.7	3.7	1.3	1.3
	SC average	0.3	0.3	1.0	1.0	1.7	0.1	2.8	2.8	36.9	36.9	24.0	22.1	4.8	13.0	1.7	1.7	2.7	2.7
	SF average	5.5	5.5	3.9	3.9	0.8	0.5	1.1	1.1	0.5	0.5	1.4	3.6	1.2	1.8	2.6	2.6	0.7	0.7
	PH average	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.0	0.3	0.3	0.0	0.0
	BS average	1.4	1.4	3.3	3.3	4.6	0.0	11.3	11.3	34.3	34.3	32.1	25.2	3.7	0.2	1.4	1.4	7.0	7.0
	SL average	0.0	0.0	4.4	4.4	327.1	4.5	589.0	589.0	114.0	114.0	328.9	157.4	55.04	58.2	0.3	0.3	0.0	0.0
	PS* average	37.3	37.3	270.7	270.7	1.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	CS* average	62.1	62.1	54.9	54.9	0.3	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<u>GILLNETS</u>																			
A	BC average	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.04	0.04	0.2	0.1	0.4	0.2	0.5	0.5	0.0	0.0
	LC average	0.1	0.1	0.2	0.2	0.5	0.1	1.1	1.1	0.2	0.2	0.6	0.5	0.4	0.8	2.5	2.5	0.0	0.0
	SC average	0.8	0.8	0.5	0.5	0.7	0.4	1.0	1.0	0.2	0.2	0.6	0.4	1.0	1.4	3.0	3.0	1.0	1.0
	SF average	0.7	0.7	0.8	0.8	0.2	0.7	0.2	0.2	1.0	1.0	0.4	0.2	0.3	0.4	0.2	0.2	0.1	0.1
	PH average	0.6	0.6	1.7	1.7	0.03	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.5	4.7	4.7	0.5	0.5
	BS average	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.2	0.2	0.2	0.4	0.4

*juvenils only

Table 29 Sample size, range, standard deviation and mean lengths (mm) by geartype of finfish species captured in nearshore waters of Norton Sound from June through October, 1977.

SPECIES	BEACH SE NE				FLOATING GILLNET				SINKING GILLNET				FLOATING+SINKING			
	N	LENGTH RANGE	MEAN	SD	N	LENGTH RANGE	MEAN	SD	N	LENGTH RANGE	MEAN	SD	N	LENGTH RANGE	MEAN	SD
PINK SALMON	420	27-71	39	8.1	18	33-47	42.1	32.9	0	0-0	0	0	18	33-47	42.1	32.9
CHUM SALMON	407	25-68	42	7.1	16	55-67	58.5	30.7	0	0-0	0	0	16	55-67	58.5	30.7
SILVER SALMON	5	109-26	119	6.7	7	490-615	560	38.8	0	0-0	0	0	7	490-615	560	38.8
RED SALMON	0	0-0	0	0	1	617-617	617	0	0	0-0	0	0	1	617-617	617	0
HUMPBACK WHITEFISH	198	72-418	174	112.6	34	114-465	326	74.2	4	12-371	295	87.8	138	114-465	326	74.2
BROAD WHITEFISH	82	70-400	270	103.9	14	194-490	364	81.1	3	03-347	205	126.7	17	103-490	364	81.1
ROUND WHITEFISH	17	91-390	233	90.8	10	167-382	298	74.5	1	61-161	161	0	11	161-382	286	81.9
BERING CISCO	285	51-374	173	86.1	178	67-408	252	86.9	23	17-360	257	64.7	201	67-408	253	84.6
LEAST CISCO	463	66-330	156	69.2	27	100-415	237	58.2	21	58-282	212	27.7	292	100-415	235	56.9
STARRY FLOUNDER	329	31-51	156	80.7	312	43-491	255	92.8	85	157-465	314	68.2	397	43-491	268	91.3
ARCTIC FLOUNDER	99	24-98	121	59.4	100	69-300	177	49.1	3	72-111	88	20.6	103	69-300	175	50.7
ALASKA PLAICE	10	60-155	99	34.7	1	64-64	64	0	1	132-132	132	0	2	64-132	98	48.1
YELLOWFIN SOLE (MURDAH)	11	81-155	119	23.9	3	07-164	137	28.6	13	93-254	146	51.6	16	93-254	145	38.8
TUBENOSE POACHER	96	37-147	81	18.8	131-131	131	0	0	0	0-0	0	0	1	31-1	131	0
BERING POACHER	27	53-120	73	13.9	0-0	0	0	0	0	0-0	0	0	0	0-0	0	0
CAPELIN	1	69-69	69	0	0	0-0	0	0	0	0-0	0	0	0	0-0	0	0
BOREAL SMELT	2064	10-269	49	26.0	69	122-288	182	44.1	58	136-277	189	40.5	127	122-288	185	42.5
POND SMELT	2733	22-136	55	19.9	21	108-146	119	8.1	19	110-125	117	3.6	40	108-146	118	6.3
SANDLANCE	795	27-137	63	14.3	0	0-0	0	0	0	0-0	0	0	0	0-0	0	0
THREESPINE STICKLEBACK	132	16-93	29	16.8	0	0-0	0	0	0	0-0	0	0	0	0-0	0	0
NINESPINE STICKLEBACK	473	20-80	45	9.6	0	0-0	0	0	0	0-0	0	0	0	0-0	0	0
WHITESPOTTED GREENLING	5	88-216	151	62.3	5	111-274	204	60.6	26	153-310	222	45.1	31	111-310	219	47.2
ROCK GREENLING	2	84-97	91	9.2	18	116-281	213	43.8	6	58-215	156	59.4	24	58-281	198	53.2
ARCTIC CHAR	45	99-640	297	168.9	184	39-598	404	85.2	0	0-0	0	0	184	139-598	404	85.2
SAFFRON COD	833	32-358	112	63.0	412	0-420	253	50.8	167	92-362	25	50.8	579	92-420	252	50.7
SCULPIN	39	24-435	149	107.0	59	84-542	225	117.6	2	127-480	274	01.9	71	84-542	233	15.9
PRICKLEBACK	71	208-420	294	50.5	2	234-235	235	0.7	0	0-0	0	0	2	234-235	235	0.7
NORTHERN PIKE	330-330	330	330	0	0	0-0	0	0	0	0-0	0	0	0	0-0	0	0
NORTHERN SUCKER	1	110-110	110	0	0	0-0	0	0	0	0-0	0	0	0	0-0	0	0
MORFETSH	0	0-0	0	0	0	0-0	0	0	1	540-540	540	0	1	540-540	540	0

Table 30. Sample size, range, standard deviation and mean lengths (mm) by gear type of finfish species captured in Port Clarence, Grantley Harbor and Imuruk Basin from June through October, 1977.

SPECIES	BEACH NET				FLOATING GILLNET				SINKING GILLNET				FLOATING+SINKING			
	N	LENGTH RANGE	MEAN	SD	N	LENGTH RANGE	MEAN	SD	N	LENGTH RANGE	MEAN	SD	N	LENGTH RANGE	MEAN	SD
PINK SALMON	3	35-51	45	9.0	7	332-443	415	38.5	0	0-0	0	0.0	7	332-443	415	38.5
CHUM SALMON	3	48-53	50	2.6	5	560-676	591	48.7	0	0-0	0	0.0	5	560-676	591	48.7
SILVER SALMON	0	0-0	0	0.0	3	490-615	563	64.9	0	0-0	0	0.0	3	490-615	563	64.9
RED SALMON	0	0-0	0	0.0	1	617-617	617	0.0	0	0-0	0	0.0	1	617-617	617	0.0
HUMPBACK WHITEFISH	6	314-388	362	25.2	19	257-416	336	35.8	1	342-342	342	0.0	20	257-416	336	35.8
BROAD WHITEFISH	47	78-400	311	81.1	8	245-490	304	71.4	3	103-347	205	126.7	11	103-490	320	110.6
ROUND WHITEFISH	17	51-390	233	90.8	9	47-382	312	64.8	1	161-161	161	0.0	10	161-382	297	77.5
PETING CUSCO	07	67-374	239	67.6	89	64-378	235	72.7	7	223-360	286	43.0	106	104-378	285	68.6
LEAST CUSCO	96	60-312	177	72.4	95	55-386	238	44.7	2	158-282	222	29.5	107	115-386	254	44.6
STARRY FLOUNDER	28	10-451	246	22.8	68	43-491	303	80.2	34	262-452	330	51.0	92	43-491	312	72.8
ARCTIC FLOUNDER	18	4-64	156	54.4	17	84-238	170	39.4	0	0-0	0	0.0	17	84-238	170	39.4
ALASKA PLATICE	3	52-260	144	27.4	1	64-64	64	0.0	0	0-0	0	0.0	1	64-64	64	0.0
YELLOWFIN SOLE (MUDDA)	0	10-10	0	0.0	1	0-10	107	0.0	0	0-0	0	0.0	1	07-107	107	0.0
TUBENOSE POACHER	19	62-108	81	15.2	0	0-0	0	0.0	0	0-0	0	0.0	0	0-0	0	0.0
BERING POACHER																
CAPELIN	1	69-69	69	0.0	0	0-0	0	0.0	0	0-0	0	0.0	0	0-0	0	0.0
BOREAL SMEL	1215	21-269	44	26.4	17	138-288	224	53.3	36	140-277	198	40.4	53	138-288	206	46.1
POND SMELT	2540	21-125	55	20.3	12	108-128	117	5.4	18	110-125	118	3.7	30	108-128	117	4.4
SANDLANCE	346	41-113	63	11.3	0	0-0	0	0.0	0	0-0	0	0.0	0	0-0	0	0.0
THREESPIN STICKLEBACK	132	16-93	29	6.8	0	0-0	0	0.0	0	0-0	0	0.0	0	0-0	0	0.0
NINESPIN STICKLEBACK	311	23-80	44	9.4	0	0-0	0	0.0	0	0-0	0	0.0	0	0-0	0	0.0
WHITE SPOTTED GREENLING	2	84-97	91	9.2	4	116-201	164	39.2	4	5-189	133	6.3	8	5-201	149	50.3
ROCK GREENLING																
ARCTIC CHAR	16	37-58	87	106.0	15	139-598	313	133.4	0	0-0	0	0.0	15	139-598	313	133.4
SAFFRON COD	476	57-358	104	55.7	23	139-420	279	5.5	95	92-362	261	47.2	218	92-420	271	50.3
SCULPIN	20	24-396	126	95.2	20	06-264	192	40.6	0	0-0	0	0.0	20	106-264	92	40.6
PRICKLEBACK																
NORTHERN PIKE	1	330-330	330	0.0	0	0-0	0	0.0	0	0-0	0	0.0	0	0-0	0	0.0
NORTHERN SUCKER	1	10-110	0	0.0	0	0-0	0	0.0	0	0-0	0	0.0	0	0-0	0	0.0
LOW ESTIM																

Table 31. Sample size, range, standard deviation and mean lengths (mm) by gear type of finfish species captured from Bluff to Cape Darby (Golovin Bay area) from June through October, 1977.

SPECIES	DEEP JELLY				JELLY GILLNET				FLUORID JELLYNET			
	N	LENGTH RANGE	MEAN	SD	N	LENGTH RANGE	MEAN	SD	N	LENGTH RANGE	MEAN	SD
PINK SALMON	404	27-71	39	8.1	0	0-0	0	0.0	0	0-0	0	0.0
CHUM SALMON	374	25-68	42	7.2	0	0-0	0	0.0	0	0-0	0	0.0
SILVER SALMON	5	65-126	19	6.7	0	0-0	0	0.0	0	0-0	0	0.0
RED SALMON												
BUMPBACK WHITEFISH	179	73-390	159	100.2	109	114-415	315	76.4	3	172-371	279	100.3
BROAD WHITEFISH	22	148-378	273	87.8	3	194-447	316	126.8	0	0-0	0	0.0
ROUND WHITEFISH												
HERING, CISCO	106	88-358	142	69.1	33	100-365	216	79.7	4	117-248	178	53.7
LEAST CISCO	263	63-285	139	60.4	104	100-285	202	41.6	9	178-235	197	17.8
STARRY FLOUNDER	244	30-640	150	62.3	78	105-340	164	40.7	40	17-465	312	79.7
ARCTIC FLOUNDER	50	24-298	99	61.7	43	89-300	177	55.2	1	72-72	72	0.0
ALASKA PLATICE	7	60-93	80	12.0	0	0-0	0	0.0	0	0-0	0	0.0
YELLOWFIN SOLE (MUDDAU)	1	25-125	125	0.0	0	0-0	0	0.0	12	93-254	150	41.0
TURNOSE POACHER	71	37-120	80	7.8	1	3-3	31	0.0	0	0-0	0	0.0
HERING POACHER	1	120-120	120	0.0	0	0-0	0	0.0	0	0-0	0	0.0
CAPELIN												
BORNEAL SMELT	595	10-160	51	17.5	46	122-250	170	31.1	22	136-251	174	37.0
POND SMELT	189	31-136	60	13.0	7	110-146	123	11.6	1	116-116	116	0.0
SANDLANCE	251	47-137	70	17.2	0	0-0	0	0.0	0	0-0	0	0.0
TURKISH SPINE STICKLEBACK												
NINE SPINE STICKLEBACK	158	20-71	46	9.7	0	0-0	0	0.0	0	0-0	0	0.0
WHITE SPOTTED GREENLING	5	88-216	151	62.3	5	111-274	204	60.6	26	153-30	222	45.1
ROCK GREENLING												
ARCTIC CHAR	21	99-640	335	175.2	24	264-560	404	74.2	0	0-0	0	0.0
SAFFRON COD	58	37-297	108	59.5	255	110-394	243	47.4	63	109-355	236	48.8
SCULPIN	14	40-435	92	14.3	23	100-520	253	88.9	0	27-480	279	2.0
PRICKLEBACK												
NORTHERN PIKE												
NORTHERN SUCKER												
WOLF FISH	0	0-0	0	0.0	0	0-0	0	0.0	1	540-540	540	0.0

Table 32 Sample size, range, standard deviation and mean lengths (mm) by gear type for finfish species captured in nearshore waters of southern and eastern Norton Sound (area B,C,D) from June through October 1977

SPECIES	BRACHT LINE				FLOATING GILLNET				SINKING GILLNET				FLOATING+SINKING			
	N	LENGTH RANGE	MEAN	SD	N	LENGTH RANGE	MEAN	SD	N	LENGTH RANGE	MEAN	SD	N	LENGTH RANGE	MEAN	SD
PINK SALMON	13	29-33	32	1.8	11	37-47	43	27.9	0	0-0	0	0	1	37-47	43	27.9
CHUM SALMON	30	33-40	37	2.1	11	51-61	58	20.8	0	0-0	0	0	1	51-61	58	20.8
SILVER SALMON	0	0-0	0	0	4	53-56	55	13.8	0	0-0	0	0	4	53-56	55	13.8
RED SALMON																
HUMPHREY WHITE SH	13	72-84	299	44.5	6	37-46	41	31.0	0	0-0	0	0	6	37-46	41	31.0
BROAD WHITE SH	13	70-84	118	89.4	3	37-45	41	37.6	0	0-0	0	0	3	37-45	41	37.6
ROUND WHITE SH	0	0-0	0	0	1	17-17	17	0	0	0-0	0	0	1	17-17	17	0
BURRING CUSCO	2	51-53	122	72.2	56	61-408	220	92.6	2	10-17	17	0	58	61-408	218	91.4
LEAST CUSCO	4	188-30	279	64.9	72	122-415	260	69.5	0	0-0	0	0	72	122-415	260	69.5
STARRY FLOUNDER	57	31-39	139	97.7	166	97-460	278	86.5	11	157-360	274	54.9	177	97-460	278	86.5
ARCTIC FLOUNDER	31	31-23	135	43.5	40	81-300	180	46.6	2	80-111	96	21.9	42	80-300	176	49.1
ALASKA PLACI	0	0-0	0	0	0	0-0	0	0	1	132-132	132	0	1	132-132	132	0
YELLOWFIN SOLE (MUDDAU)	10	81-115	119	25.1	2	140-164	152	17.0	1	100-100	100	0	3	100-164	135	32.3
TUBENOSE POACHER	6	60-117	94	34.7	0	0-0	0	0	0	0-0	0	0	0	0-0	0	0
BURRING POACHER	26	53-93	71	10.4	0	0-0	0	0	0	0-0	0	0	0	0-0	0	0
CAPELIN																
BOREAL SMELT	254	15-17	62	33.6	6	127-162	49	12.3	0	0-0	0	0	6	127-162	149	2.3
PORD SMELT	4	53-55	59	5.7	2	115-119	17	2.8	0	0-0	0	0	2	115-119	117	2.8
SANDLANCE	198	27-33	56	10.8	0	0-0	0	0	0	0-0	0	0	0	0-0	0	0
THREESPINE STICKLEBACK																
NINESPINE STICKLEBACK	4	40-44	55	10.3	0	0-0	0	0	0	0-0	0	0	0	0-0	0	0
WHITE SPOTTED GREENLING																
ROCK GREENLING	0	0-0	0	0	14	72-281	227	34.8	2	185-215	200	21.2	16	172-281	223	34.1
ARCTIC CHAR	8	00-58	419	37.5	45	222-569	413	75.3	0	0-0	0	0	45	222-569	413	75.3
SAFFRON COD	199	42-34	134	75.9	34	126-321	235	37.5	9	118-228	183	45.2	43	118-321	224	44.2
SCULPIN	5	64-77	12	54.4	6	84-542	226	76.9	2	248-256	252	5.7	18	84-542	229	166.4
PRICKLEBACK																
NO HORN PKE	208-40	0	294	50.5	2	34-235	33	0.7	0	0-0	0	0		234-235	23	0.7
NORTHERN SUCKER																
MORFISH																

table 33. Surface water temperatures (C°) at various coastal sampling locations in Norton Sound from June 1 through October 16, 1977 (OCS/RU19).^{1/}

Date	(A) Golovin Bay	(B) C. Denbigh to Egavik	(C) Egavik to Toistol Pt.	(D) Toistol Pt. to C. Stebbins	(E) Port Clarence	(F) Grantley Harbor	(G) Imuruk B a s i n
6/1-6/15	6.6° (33/10) ^{2/}	7.5° (14/6) ^{3/}	3.6° (15/7) ^{5/}	1.3° (11/5) ^{7/}			
6/15-6/30	12.0° (28/10)			6.8° (10/6) ^{8/}		12.8° (6/5)	
7/1-7/15	12.8° (44/10)				10.0° (16/9)	13.4° (14/7)	16.1° (5/5) ^{11/}
7/16-7/31		16.0° (15/6)	14.5° (18/7)				
8/1-8/15				11.0° (21/10)			
8/16-8/31	13.0° (32/10)	13.0° (2/1) ^{4/}	14.0° (2.1) ^{6/}		13.7° (27/9) ^{9/}	12.7° (26/9)	12.3° (11/4) ^{12/}
9/1-9/15	10.4° (18/10)						
9/16-9/30	4.8° (22/8)					3.8° (15/5) ^{10/}	
10/1-10/16	1.8° (26/10)				3.6° (24/9)		3.1° (10/4) ^{13/}

^{1/} Numbers in parentheses: (number of surface water readings/number of locations where readings were taken).

^{2/} Readings from 6/9-6/15 only.

^{3/} Readings on 6/15 and 6/16 only.

^{4/} Readings on 8/9 only.

^{5/} Readings from 6/1-6/10 only.

^{6/} Readings on 8/10 only.

^{7/} Readings on 6/12 only.

^{8/} Readings from 6/18-6/20 only.

^{9/} Readings from 8/20-8/23 only.

^{10/} Readings from 9/27 -9/29 only.

^{11/} Readings on 7/10 only.

^{12/} Readings on 8/30 only.

^{13/} Readings on 10/1 only.

Table 34. Surface salinity readings (ppt) at selected stations in Norton Sound from June through September, 1976.

Date	Stations															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
June	23					3.7										
	24					4.6										
	25							13.2								
	26													0.7		
	28				13.7	13.5	13.3									
July	1					12.9										
	2											15.3	17.4			
	5								13.5	13.0	13.7					
	6							15.3								
	10	13.4	13.4	13.4	13.3	13.2	13.3								13.5	27.2
	11-14															
	16						13.7	14.1								
	18							14.0	14.9	14.8						
	21						13.5				15.1	15.1	15.1			
	25						11.0									
	26					13.9	8.1									
	27				15.1	14.6	9.3									
August	28			16.3				15.5	15.0	14.8	15.7	15.5	14.9			
	4									15.8	15.5	15.4		16.6	16.4	
	5															
	8					15.5	15.5	15.7								
	9					10.5										
	12	17.0	16.9													
	13			16.8												
	24				19.5	16.8	16.5									
	26	19.6	19.6	19.5		19.6	18.9									
	27						9.0	18.7								
	28								15.7	18.5	18.3	10.8				
	29												18.3	18.3		
September	30									18.1						
	31							19.2	18.9							
	7	19.7	20.1			18.9										
	9					19.5										
Mean	10					11.2	19.4	18.0								
	Mean	17.4	17.5	16.5	15.4	15.3	17.7	16.3	15.4	16.2	16.0	614.0	16.30	16.8	-	-

Stations 1-14 occur in nearshore waters of eastern Norton Sound from Tolstoi Point to Cape Denbigh. Station 15 was in Golovin lagoon near the village of Golovin. Station 16 was at the jetties in Nome.

Table 35. **Finfish** catches of variable mesh **gillnets** during offshore sampling in Norton Sound from June 22 through July 12, 1977.

Station	Date	Time of Set	Hours Fished (1/10)	Station Depth (1/10 Fathoms)	Surface Water Temperature (C)	Catch							
						PH	BC	AC	CS	SS	SF	PS	CT
G 1	6/22	2125	9.7	13.0	8	103		3					
G 2	6/23	2035	11.0	6.5	8								1
G 3	6/24	2000	4.2	6.0	13	9							
G 4	6/25	0040	5.5	6.5	12	10							
G 5	6/25	1830	1.8	8.0	15	1		1					
G 6	6/26	2040	9.8	6.0	13	4	2						
G 7	6/27	2035	0.8	11.0	14	2	1						
G 8	6/28	2045	1.0	9.0	6	4		1	1				
G 9	6/30	2240	8.6	10.0	3								
G 10	7/1	2100	2.8	10.0	6					1			
G 11	7/2	2300	9.5	5.0	11	1					1		
G 12	7/3	1055	5.4	2.0	8						6		
G 13	7/3	1745	13.8	5.0	12		1						
G 14	7/4	1525	4.3	2.5	9				1				
G 15	7/5	2100	10.8	3.0	8			1			1		
G 16	7/6	0945	23.0	3.5	7								
G 17	7/7	1945	12.5	20.0	5								
G 18	7/8	2015	11.1	18.0	4								
G 19	7/9	1905	12.5	14.0	13	4		1					
G 20	7/10	2000	11.0	8.5	14	156	1	3		1			
G 21	7/11	1930	12.1	7.0	13								
G 22	7/12	1945	11.7	8.0	15	21		1				1	
Ave.			10.6	Ave. 8.3	Ave. 9.9	315	5	11	2	2	8	1	1

Table 36. **Mean** length (mm) and weight (gins) of herring captured with **gillnets** in the offshore surface waters of Norton Sound from June 22 through July 12, **1977**.

Stations		Age Class							
		III	IV	v	VI	VII	VIII	IX	x
G1 n=101	length			222	235	245	255	264	268
	weight			141	169	196	221	243	261
G2-G19 n=35	length	181		225	225	262	256		271
	weight	65		127	124	199	201		222
G20-G21 n=155	length	176	196	218	225	232	237	262	244
	weight	64	88	124	137	150	160	212	175
G22 n=20	length	173	183	176					
	weight	63	76	66					

Table 37. Relative maturity (percent composition) by gillnet station of herring captured in offshore surface waters of **Norton** Sound from June 22 through July 7, 1977.

Relative Maturity Index	Gillnet Station							Total Percent
	1	3	4	6	19	20	22	
Virgin 1	0	0	0	0	0	0	0	0
Herring 2	0	71	100	33	0	8	44	13
Pre-Spawners 3	4	0	0	0	0	34	31	21
4	30	0	0	0	0	0	0	10
Spawners 5	66	29	0	33	0	0	0	23
6	0	0	0	3	4	0	0	1
Post-Spawners 7	0	0	0	0	0	3	0	2
8	0	0	0	0	100	55	25	30
Sample	81	7	10	3	1	125	16	100

Table 38. Relative maturity (percent composition) by age class of herring captured in offshore surface waters of Norton Sound from June 22 through July 7, 1977.

Relative Maturity Index	Age Class								Total Percent
	III	IV	V	VI	VII	VIII	IX	X	
Virgin Herring									
1	0	0		0	0	0	0	0	0
2	100		30	17	8	3	6	0	17
Pre-Spawners									
3	0	20	23	27	17	17	18	17	21
4	0	0	5	14	23	8	18	17	10
Spawners									
5	0	0	11	14	34	58	55	50	23
6	0	0	1	0	0	0	0	0	TR
Post-Spawners									
7	0	0	1	3	3	3	0	0	2
8	0	50	42	35	20	8	9	0	30
Sample	4	20	94	37	35	36	11	6	100

Table 39. Selectivity of **gillnet** mesh size on **finfish** captured in the offshore surface waters of Norton Sound from June 22 through July 12, 1977.

Mesh size (mm)	Total weight all species (kg)	Total catch all species	Catch by species							
			PH	BC	AC	CS	SS	PS	SF	CT
25	0.02				1*					
38	6.19	68	63	3	1*		1*			
51	33.36	216	213		3					
64	14.38	48	39	1	3				5	
76	10.28	7		1		2		1	3	
102	2.12	3			3					
114	4.00	1					1			
133		1								1
Total	70.36	345	315	5	11	2	2	1	8	1

* Indicates juvenile fish.

Table 40. Frequency of occurrence (percent) of species encountered with a surface tow net in the offshore waters of Norton Sound from June 22 through July 12, 1977.

	Number of tows captured in	Frequency of occurrence (%)
Fi nfi sh		
Larval fi sh	55	66
S9	8	10
SF	5	6
WF	3	4
Sc	1	1
Ps	1	1
Lamprey	2	2
Mi scel l aneous speci es		
Jelly fi sh	49	59
Snails	12	14
Larval crabs	4	5
Polychaete worms	2	2
Shri mp	1	1
Nudibranchs	2	2
Uni denti fi ed crustacea	3	4
Uni denti fi ed mol l usks	1	1
No Catch	5	6

Table 41. Catch by species and sample station of fish captured in the Yukon River 101 kilometers upriver from Flat Island from June 7-July 7, 1977.

Station	Species								Total	Lamprey	Grand Total
	CS	SS	KS	PS	<u>Wsp.</u> ^{1/}	SH	LL	NS			
1	36	1	1	2	234	24	100	1	399	2	401
2	45		2		237	23	88		395		395
3	47		2	2	205	19	53		328	2	330
4	29		4	1	102	7	55		198		198
5	25		2		80	10	37		154		154
6	45		1		115	11	39		211		211
7	20	1	1	1	63	2	14		102		102
8	28	2	1		57	1	34		123	1	124
Totals	275	4	14	6	1,093	97	420	1	1,910	5	1,915

^{1/} **Wsp** - represents whitefish species.

Table 42. Catch by date of juvenile finfish captured in the Yukon River 101 kilometers upriver from Flat Island from June 7 through July 7, 1977.

Date	Species								
	CS	SS	KS	PS	Wsp. 1/	SH	LL	NS	1 amp.
6/7	1								
8	11		1						3
9	15				1				
10 2/	-	-	-	-	-	-	-	-	-
11	29	1	2	2					2
12	27	2							
13	36	1	1	1					
14	-	-	-	-	-	-	-	-	-
15	34		2						
16	21		1						
17	-	-	-	-	-	-	-	-	-
18	26								
19	-	-	-	-	-	-	-	-	-
20	12		1	1					
21	15		1	1					
22	3								
23	24				20			1	
24	12		1		36				
25	-	-	-	-	-	-	-	-	-
26	2		1		46				
27	6				54		1		
28	-	-	-	-	-	-	-	-	-
29	-	-	-	-	-	-	-	-	-
30	-	-	-	-	-	-	-	-	-
7/1					114		26		
2	1				197	10	42		
3			1		162	21			
4			1		206	23	1		
5					89	12	62		
6					70	10	42		
7			1		98	21	53		
Total	275	4	14	6	1,093	97	420	1	5

1/ Wsp. - Whitefish species.

2/ Dates not fished.

Table 43. Sample size, range, mean length, and standard deviation of finfish captured in the Yukon River 101 kilometers upstream from Flat Island from June 7 through July 7, 1977.

Species	Sample	Fork Length Range (mm)	Mean Fork Length (mm)	Standard Deviation	Additional Samples	
					Sample	Fork Length Range (mm)
CS smelt	265	31-58	41	4.8		
KS smelt	14	75-112	96	12.1		
Ps Smelt	6	32-42	35	--		
SS smelt	4	46-54	50	--		
SH juveniles	92	35-74	56	7.5		
Wsp. juveniles^{1/}	89	20-51	34	7.1	468	20-45
LL juveniles^{2/}	35	18-32	23	3.4	88	19-25
Lamprey					5	120-140
BW	1		120			
NS	1		49			

^{1/} **Wsp.** - whitefish species

^{2/} An additional specimen measured 105 mm.

Table 44. Subsistence fishery resources of selected coastal villages in Norton Sound and Kotzebue Sound. Information from 1976 OCS subsistence surveys.

Village	Herring	Smelt species	Tomcod	Saffron Cod	Flounder species	Arctic grayling	Arctic char (trout)	Whitefish species	Cottidae	Skipjacks	Northern pike	Cigarfish (Capelin?)	Capelin	Mud sucker	Blue cod	P. flack	Halibut	Blackfish species	Needlefish	Sheefish	Lingcod	King crab
Stebbins	Sp	F, W	W	Su			Su, F	Su, F	Su								X	X	F	F		
St. Michael	Sp		W	W				Su, F														
Unalakleet	Sp	K	W	Su	Su, F	Su, F	Su, F	Su, F														Sp
Shaktoolik	Sp	K	W	Su	Su, F	Su, F	Su, F	Su, F														
Koyuk*		K	X		X	X														X		
Moses Pt.	Sp	Sp, Su	W, Sp	Su	F	Su, F	F, W	Su	F												X	
Elim	Sp	Sp, Su	W, Sp	Su	F	Su, F	F, W	Su	F			X									X	
Golovin	Sp, F	X	W		W	Su, F, W	F					X										Sp
Nome*	X		X		X	X							Su ^{1/}									W
Teller	Sp, F	Sp, F	W	Su	Su, F	Su, F	S, S, F, W	X	F	X											X	
Shishmaref	F, W, Sp	S, S, F, W	F, W	F	F	F	X		Sp, Su						W						F, W	
Deering	Su, F	Su, F	W	Su	Su, F	Su, F	Sp, Su	Su				X										
Buckland	Su, F	Sp	W	Su, F	Su, F	Su, F	F	Su, F			X			X		X						
Kotzebue*	X	X	X		X	X														X		
Pt. Nepe*		X	X		X																	

* Villages that were not included in 1976 OCS survey. Information from ADF&G files.

^{1/} Capelin are taken in Nome only in some years.

Code: Sp - Spring (3-4 weeks immediately following ice breakup)

Su - Summer

F - Fall (3-4 weeks immediately preceding ice freezeup)

W - Winter (ice freezeup to ice breakup)

X - Resource used for subsistence. Dates of harvest not obtained.

Various species of salmon are utilized by all villages for subsistence purposes.

Table 45. Standard length comparisons of Pacific herring from selected Bering Sea areas.

Age Class	Port Clarence 1977	Norton Sound		Yukon-Kuskokwim River Delta and Bristol Bay						North Alaska Peninsula 1976	
		Gołovin Bay 1977 ^{1/}	St. Michaels 1968	Nelson Island 1976	Goodnews Bay 1976	Togiak Area					
						1968	1969	1974	1976		1977
0	90 ^{2/}	50 ^{3/}									
1	114	150									151
2	159	175						141			156
3	164	184		200	219	216	203		209		182
4	173	198	208	228	222	238	245	217	217	229	205
5	183	219	227	231	222	253	256	234	244	232	216
6	200	225	231	248	246	262	277	249	237	248	230
7	202	240	236	267	288	272	280	261	286	268	262
8	204	252	244	277	281	282	290	267	281	276	256
9	207	259	250	295	284	289	314	275	291	276	261
10	211	272	244	263		297	303	268	290	271	265
11	229		260			300	305				
12	228		275			305	312		302		
13	228					302	310				
14	244										
15	240						330				
Sample size	834	472	350	45	56	673	403	451	54	2,670	1,198

^{1/} Includes offshore herring samples collected in eastern Norton Sound in June.

^{2/} Measurements taken from September 29 to October 5.

^{3/} Measurements taken on September 8.

Table 46. Standard length comparisons of herring from selected Pacific Ocean and Bering Sea areas.

	Age Class	Port Clarence	Eastern Norton Sound	Yukon-Kuskokwim Delta <u>3/</u>	Togiak <u>3/</u>	North Alaska Peninsula <u>4/</u>	Prince William Sound <u>5/</u>	Southeast Alaska <u>6/</u>	British Columbia <u>6/</u>
	0	90^{1/}	50^{2/}						
198	1	14	150			151			148
	2	59	175		141	156		152	186
	3	64	184	210	209	182	177	176	194
	4	73	203	225	229	205	189	198	203
	5	183	223	227	244	216	199	207	215
	6	200	228	247	255	230	209	223	220
	7	202	238	278	273	262	214	222	223
	8	204	248	279	279	256	221	238	220
	9	207	255	290	289	261	231	236	
	10	211	258	263	286	265		237	
	11	229	260		303		215		
	12	228	275		306				
	13	228			306				
	14	244							
	15	240			330				
	Sample	834	822	101	4, 257	1, 198	417		

1/ Measurements taken from September 29 to October 5, 1977.

2/ Measurements taken on September 8, 1977.

3/ Data from Barton et al. 1976.

4/ Data from Warner and Shafford 1977,

5/ Data from Fridgen, personal communication.

6/ Data from Randall 1975.

Table 47. Variation in number of herring vertebrae from samples collected at selected sites along the North American Pacific Coastline (data from **Rounsefell**, 1930).

Area	Local it y	Number	Mean	Probable Error	Standard Deviation of Di stribution
Cal i forni a	San Diego Bay	408	50. 68	0. 023	0. 691
Cal i forni a	Monterey Bay	89	51. 03	0. 06	---
Cal i forni a	San Francisco Bay	820	50. 78	0. 019	0. 797
Washington	Puget Sound	100	51. 71	0. 052	0. 758
British Columbi a	South British Columbi a	1, 263	51. 78	0. 01	---
Southeastern Al aska	Gravina Isl and	50	52. 32	0. 075	0. 786
Southeastern Al aska	Craig	344	52. 40	0. 026	0. 712
Southeastern Al aska	Larch Bay	463	52. 66	0. 021	0. 681
Southeastern Al aska	Tebenkof Bay	683	52. 68	0. 018	0. 683
Southeastern Al aska	Point Gardner	352	52. 72	0. 023	0. 634
Southeastern Al aska	Whale Bay	25	52. 92	0. 078	0. 580
Southeastern Al aska	Stephens Passage	962	52. 36	0. 017	0. 769
Southeastern Al aska	Yakutat Bay		52. 48	0. 163	0. 205
Prince William Sound	Puget Bay	1; ?	52. 45	0. 038	0. 750
Prince William Sound	Elrington Passage	401	52. 76	0. 024	0. 719
Prince William Sound	Macleod Harbor	367	52. 72	0. 027	0. 755
Prince William Sound	Snug Harbor	322	52. 55	0. 029	0. 772
Prince William Sound	Eshamy Bay	150	52. 83	0. 035	0. 636
Prince William Sound	McClure Bay	224	52. 90	0. 030	0. 657
Prince William Sound	Naked Island	138	52. 80	0. 040	0. 693
Prince William Sound	Port Fidalgo	137	52. 44	0. 040	0. 692
Cook Inlet	Dogfish Bay	100	52. 50	0. 051	0. 763
Cook Inlet	Kachemak Bay	740	52. 76	0. 031	0. 790
Kodi ak	Shuyak Strait	531	52. 72	0. 022	0. 757
Kodi ak	Zachar Bay	87,	52. 85	0. 048	0. 670
Kodi ak	Shearwater Bay	165	52. 91	0. 041	0. 776
Kodi ak	Old Harbor	115	52. 95	0. 050	0. 790
Al aska Peni nsul a	Chignik	107	53. 33	0. 053	0. 806
Al aska Peni nsul a	Shumagin Isl ands	456	54. 67	0. 029	0. 928
Al aska Peni nsul a	Belkofski Bay	8	53. 13	...	---
Al aska Peni nsul a	Unalaska	183	53. 22	0. 032	0. 650
Norton Sound	Golovin Bay	140	52. 79	0. 038	0. 671

Table 48. Rank order by frequency of occurrence (percent) of the 20 most common species captured in beach seines in the nearshore waters of Norton Sound, 1976-1977.

Rank	Species	All areas combined	Golovin Bay area	South and eastern Norton Sound	Pt. Clarence Area
1	Boreal smelt	44.2	31	75	32
2	Saffron Cod	42.4	37	48	48
3	Bering cisco	42.1	41	51	33
4	Starry flounder	41.4	52	34	27
5	Ninespine sticklebacks	25.5	31	16	25
6	Pond smelt	24.1	15	17	57
7	Sand lance	23.1	34	3	24
8	Arctic flounder	23.0	25	39	14
9	Tubenose poacher	23.0	31	14	16
10	Least cisco	22.7	25	13	25
11	Sculpins	20.1	19	12	19
12	Pink salmon *	16.2	25	10	5
13	Humpback whitefish	15.5	23	12	3
14	Chum salmon *	15.1	23	9	6
15	Broad Whitefish	12.6	15	9	13
16	Pacific herring*	7.2		1	27
17	Bering poacher	7.2	6	18	
18	Threespine sticklebacks	6.5	1		11
19	Arctic char	6.1	9	4	3
20	Pricklebacks	5.0		18	

* Indicates juveniles.

Table 49. Rank order by frequency of occurrence (percent) of the 20 most common species captured in variable mesh gillnets in the nearshore waters of Norton Sound, 1976-1977.

Rank	Species	All areas combined	Golovin Bay area	South and eastern Norton Sound	Pt. Clarence Area
1	Saffron cod	30.8	35	25	38
2	Starry flounder	24.6	24	23	32
3	Pacific herring	21.0	16	19	32
4	Least cisco	20.7	21	20	23
5	Bering cisco	20.3	14	24	24
6	Arctic char	14.1	10	20	9
7	Boreal smelt	13.1	8	17	16
8	Humpback whitefish	10.8	18	6	8
9	Arctic flounder	9.4	8	12	7
10	Sculpins	7.4	9	5	10
11	Broad whitefish	4.7	8	2	7
12	Pond smelt	4.4	3	3	13
13	Whitespotted greenling	4.1	10	1	
14	Yellowfin sole	4.1	3	6	1
15	Rock greenling	4.0	TR	6	7
16	Pricklebacks	2.3		5	
17	Pacific herring *	1.2		1	6
18	Round whitefish	1.2		1	5
19	Bering poacher	1.0	TR	2	
20	Sturgeon poacher	0.6	1	TR	

* Indicates juveniles.

Table 50. Rank order by frequency of occurrence (percent) of the 10 most common families of fish sampled in Norton Sound with beach seines and variable mesh gillnets, 1976-77.

Beach seine	%	Rank	%	Gillnet
Coregonidae	96	1	58	Coregonidae
Pleuronectidae	71	2	39	Pleuronectidae
Osmeridae	69	3	31	Gadidae
Gadidae	42	4	22	Clupeidae
Salmonidae ^{1/}	41	5	17	Osmeridae
Gasterosteidae	32	6	15	Salmonidae ^{1/}
Agonidae	31	7	8	Hexagrammidae
Ammodytidae	23	8	7	Cottidae
Cottidae	20	9	2	Stichaeidae
Clupeidae	10	10	2	Agonidae

^{1/} Includes only Arctic char and juvenile salmon. Adult salmon are not included.

Table 51. Abundance of Bering cisco captured in the nearshore waters of Norton Sound, 1976-77.

AREA	SAMPLING PERIOD								
	I 76 77	II 76 77	III 76 77	IV 76 77	V 76 77	VI 76 77	VII 76 77	VIII 76 77	IX 76 77
BEACH SEINES *									
A average	- 7.2	0.3	0.6 0.1	1.0 -	3.8 -	2.4 1.4	4.8 1.0	5.9	1.0
8 average	1.5 -	2.0 -	2.6 -	1.2 14.7	2.3 -	4.2 -	- -	- -	- -
c average	1.5	0.1 -	0.9 -	2.8 5.0	5.4 -	13.7 -	4.0 -	- -	- -
D average	0.0	- -	- -	0.0	- -	- -	- -	- -	- -
6 average	- -	0.2	5.3	- -	- -	0.6	- -	0.2	- -
H average	- -	6.6	6.3	- -	0.0	0.0	- -	1.3	0.0
I average	- -	- -	17.6	- -	- -	2.3	- -	0.0	- -
GILLNETS *									
A average	0.3	0.2	0.2 0.1	0.1 -	0.04 -	0.2 0.1	0.4 0.2	0.5	0.0
8 average	0.4	0.7 -	0.7 -	0.3 0.5	0.5 1.5	0.5 -	- -	- -	- -
c average	0.0	0.7 -	2.1 -	0.4 1.9	0.4 1.5	0.5 -	0.3 -	- -	- -
D average	0.0	- -	0.2 -	0.3 1.9	0.3 1.5	- -	- -	- -	- -
G average	- -	0.1	- -	0.1	- -	0.3	- -	1.0	- -
H average	- -	- -	2.4	0.0	0.0	0.7	- -	0.5	0.6
1 average	-	- -	- -	- -	- -	1.2	- -	2.7	- -

*CPUE equals fish per net hour & fish per set for gillnets and beach seines, respectively.

Table 52. Abundance of least cisco captured in the nearshore waters of Norton Sound, 1976-77.

AREA	SAMPLING PERIOD								
	<u>I</u> <u>76 77</u>	<u>II</u> <u>76 77</u>	<u>III</u> <u>76 77</u>	<u>IV</u> <u>76 77</u>	<u>V</u> <u>76 77</u>	<u>VI</u> <u>76 77</u>	<u>VII</u> <u>76 77</u>	<u>VIII</u> <u>76 77</u>	<u>IX</u> <u>76 77</u>
<u>BEACH SEINES *</u>									
A	1.3	1.9	0.1 0.6	11.8 -	23.2 -	0.4 40.9	0.8 3.4	3.7	1.3
average	1.3	1.9	0.4	11.8	23.2	20.7	2.1	3.7	1.3
B	0.5	0.0 -	0.0 -	1.0 0.7	0.0 -	0.2 -	- -	- -	-
average	0.5	0.0	0.0	0.9	0.0	0.2	-	-	-
C	0.0	0.1 -	2.4 -	0.2 0.0	0.0 -	2.9 -	1.5 -	- -	-
average	0.0	0.1	2.4	0.1	0.0	2.9	1.5	-	-
D	0.3	- -	- -	0.0	- -	- -	- -	- -	-
average	0.3	0.1	2.4	0.0	-	-	-	-	-
G	- -	3.4	0.3	- -	- -	1.6	- -	0.0	-
average	-	3.4	0.3	-	-	1.6	-	0.0	-
H	- -	0.0	1.3	- -	0.0	0.0	- -	0.0	0.0
average	-	0.0	1.3	-	0.0	0.0	-	0.0	0.0
I	- -	- -	17.6	- -	- -	24.0	- -	0.0	-
average	-	-	17.6	-	-	24.0	-	0.0	-
<u>GILLNETS *</u>									
A	0.1	0.2	0.5 0.1	1.1 -	0.2 -	0.6 0.5	0.4 0.8	2.5	0.0
average	0.1	0.2	0.3	1.1	0.2	0.6	0.6	2.5	0.0
B	0.5	0.0 -	0.0 -	0.1 1.2	0.4 0.3	0.3 -	- -	- -	-
average	0.5	0.0	0.0	0.7	0.4	0.3	-	-	-
C	0.1	0.3 -	0.2 -	0.2 1.6	0.1 0.0	0.05 -	0.1 -	- -	-
average	0.1	0.3	0.2	0.9	0.1	0.05	0.1	-	-
D	0.8	- -	0.2 -	0.3 0.4	0.3 -	- -	- -	- -	-
average	0.1	-	0.2	0.4	0.3	-	-	-	-
G	- -	2.0	- -	0.0	- -	1.0	- -	0.1	-
average	-	2.0	-	0.0	-	1.0	-	0.1	-
H	- -	- -	2.9	0.6	0.0	0.3	- -	0.2	0.0
average	-	-	2.9	0.6	0.0	0.3	-	0.2	0.0
I	- -	- -	- -	- -	- -	3.0	- -	4.0	-
average	-	-	-	-	-	3.0	-	4.0	-

*CPUE equals fish per net hours and fish per set for gillnets and beach seines, respectively.

Table 53. Abundance of boreal smelt captured in the nearshore waters of Norton Sound, 1976-77.

		SAMPLING PERIOD									
AREA		I	II	III	IV	V	VI	VII	VIII	IX	
		76 77	76 77	76 77	76 77	76 77	76 77	76 77	76 77	76 77	
BEACH SEINES *											
A	average	1.4	3.3	4.6 0.0	11.3 -	34.3 -	32.1 25.2	3.7 0.2	1.4	7.0	
B	average	9.5	3.3 -	10.3 -	49.3 21.3	19.3 -	14.6 -	- -	- -	- -	
C	average	0.0	2.9 -	107.3 -	55.4 8.0	61.4 -	63.6 -	4.5 -	- -	- -	
D	average	0.7	- -	- -	0.0	- -	- -	- -	- -	- -	
G	average	-	6.2	0.0	- -	- -	0.5	- -	0.6	- -	
H	average		1.6	0.0	- -	0.3	1.0	- -	5.5	7.8	
I	average		- -	9.6	- -	- -	2.7	- -	0.0	- -	
GILLNETS *											
A	average	0.0	0.0	0.0 0.1	0.0 -	0.0 -	0.04 0.1	0.0 0.2	0.2	0.4	
B	average	0.0	0.5 -	2.4 2.4	0.6 0.3	0.4 0.3	0.1 -	- -	- -	- -	
C	average	0.0	3.8 -	4.9 -	0.9 0.1	8.1 0.0	0.3 -	0.1 -	- -	- -	
D	average	0.0	- -	0.5 0.5	0.2 0.0	0.02 -	- -	- -	- -	- -	
G	average	-	0.7	- -	0.0	- -	0.0	- -	0.5	- -	
H	average	-	-	23.0	0.0	0.0	0.0	- -	0.4	4.0	
I	average	-	-	- -	- -	- -	0.0	- -	0.0	- -	

*CPUE equals fish per net hour and fish per set for gillnets and beach seines, respectively.

Table 54. Abundance of Pacific herring captured in the nearshore waters of Norton Sound, 1976-77.

SAMPLING PERIOD											
AREA	I	II	III	IV	V	VI	VII	VIII	IX		
	76-77	76-77	7	76-77	76-77	76-77	76			76-77	
BEACH SEINES *											
A	0.1	0.0	0.0	0.0	0.0	0.0	0.0	12.0	0.3	0.3	0.0
average	0.1	0.0	0.0	0.0	0.0	0.0	6.0		0.3		0.0
B	0.0	0.0	0.0	0.0	0.3	0.2	-	-	-	-	-
average	0.0	0.0	0.0	0.2	16.0	0.2					
C	0.0	0.0	0.0	0.2	1.5	0.1	0.0	-	-	-	-
average	0.0	0.0	0.0	0.9	0.0	0.1	0.0				
D	0.0	-	-	0.0	-	-	-	-	-	-	-
average	0.0			0.0							
G	-	3.8	0.0	-	-	2.5	-	0.7	-	-	-
average	-	3.8	0.0	-	-						
H	-	0.0	39.5	-	1.0	5.3	-	0.0	-	0.0	0.0
average	-	0.0	39.5	-	1.0			0.0		0.0	
I	-	-	7.4	-	-	40.7	-	0.0	-	-	-
average	-	-	7.4	-	-	40.7		0.0			
GILLNETS *											
A	0.6	1.7	0.03	0.0	0.0	0.0	0.1	0.5	4.7	4.7	0.5
average	0.6	1.7	0.6	0.0	0.0	0.0	0.3		4.7		0.5
B	1.7	11.8	1.1	0.4	0.3	0.1	-	-	-	-	-
average	1.7	11.8	1.1	0.4	0.05	0.1					
C	0.0	7.9	2.4	0.6	0.0	0.0	0.0	-	-	-	-
average	0.0	7.9	2.4	0.3	0.0	0.0	0.0				
D	1.3	-	1.6	1.1	0.5	0.12	-	-	-	-	-
average	1.3		1.6	0.8	0.12						
G	-	92.5	-	0.0	-	0.9	-	1.1	-	-	-
average	-	92.5		0.0		0.9		1.1			
H	-	-	48.9	-	0.0	0.6	-	2.7	-	0.5	0.5
average	-	-	48.9	0.0	0.0	0.6		2.7		0.5	
I	-	-	-	-	-	3.8	-	3.2	-	-	-
average	-	-				3.8		3.2			

*CPUE equals fish per net hour and fish per set for gillnet and beach seines, respectively.

Table 55. Abundance of saffron cod captured in the nearshore waters of Norton Sound, 1976-77.

		SAMPLING PERIOD								
AREA		<u>I</u> <u>76 77</u>	<u>II</u> <u>76 77</u>	<u>III</u> <u>76 77</u>	<u>IV</u> <u>76 77</u>	<u>V</u> <u>76 77</u>	<u>VI</u> <u>76 77</u>	<u>VII</u> <u>76</u>	<u>VIII</u>	<u>IX</u> <u>76 77</u>
BEACH SEINES *										
207	A	0.3 ^{0.3}	1.0 ^{1.0}	1.7 0.1 0.9	2.8 - 2.8	36.9 - 36.9	24.0 22.1 23 1	4.8 13.0 8.9	- 1.7 1.7	2.7 ^{2.7}
	8	0.5 ^{0.5}	0.0 - 0.0	2.1 - 2.1	15.0 124.7 69.9	0.7 - 0.7	2.8 - 2.8	- -	- -	- -
	C	0.3 ^{0.3}	0.0 - 0.0	3.5 - 3.5	34.2 15.3 24.8	30.8 - 30.8	27.0 - 27.0	29.0 - 29.0	- -	- -
	D	0.0 ^{0.0}	- -	- -	0.0 ^{0.0}	- -	- -	- -	- -	- -
	G	- -	0.0 ^{0.0}	7.3 ^{7.3}	- -	- -	25.5 ^{25.5}	- -	2.1 ^{2.1}	- -
	H	- -	0.0 ^{0.0}	1.0 ^{1.0}	- -	0.0 ^{0.0}	0.5 ^{0.5}	- -	0.3 ^{0.3}	0.3 ^{0.3}
GILLNETS *										
207	A	0.8 ^{0.8}	0.5 ^{0.5}	0.7 0.4 0.6	1.0 - 1.0	0.2 - 0.2	0.6 0.4 5	1.0 1.4 1.2	3.0 ^{3.0}	1.0 ^{1.0}
	8	0.3 ^{0.3}	1.9 - 1.9	0.6 - 0.6	0.5 0.7 0.6	0.8 0.0 4	0.6 - 0.6	- -	- -	- -
	C	0.2 ^{0.2}	0.9 - 0.9	1.0 - 1.0	0.2 0.1 0.2	0.2 0.0 0.1	0.3 - 0.3	1.7 - 1.7	- -	- -
	D	1.1 ^{1.1}	- -	1.0 - 1.0	0.5 0.1 0.3	0.2 - 0.2	- -	- -	- -	- -
	G	- -	3.9 ^{3.9}	- -	0.5 ^{0.5}	- -	1.4 ^{1.4}	- -	0.8 ^{0.8}	- -
	H	- -	- -	5.4 ^{5.4}	0.4 ^{0.4}	0.0 ^{0.0}	0.4 ^{0.4}	- -	0.5 ^{0.5}	14.8 ^{14.8}
207	1	- -	- -	- -	- -	- -	3.0 ^{3.0}	- -	2.0 ^{2.0}	- -
	average	- -	- -	- -	- -	- -	3.0	- -	2.0	- -

*CPUE equals fish per net hour and fish per set for gillnets and beach seines, respectively.

APPENDIX X FIGURES

Figure 10-1

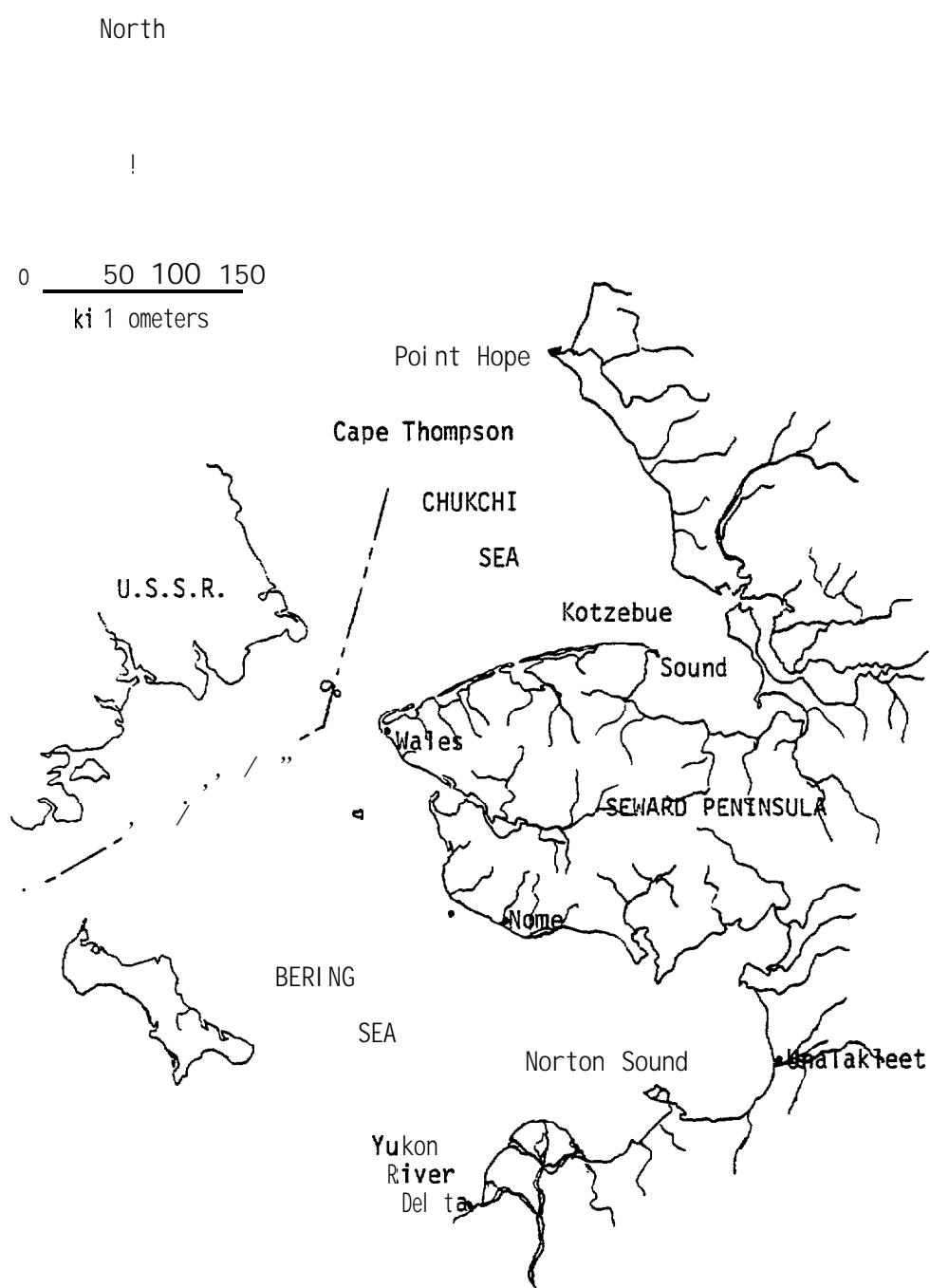


Figure 1. Study area for Research Unit 19 Finfish Resource Surveys in Norton Sound and Kotzebue Sound, 2,496 kilometers, 1976-77.

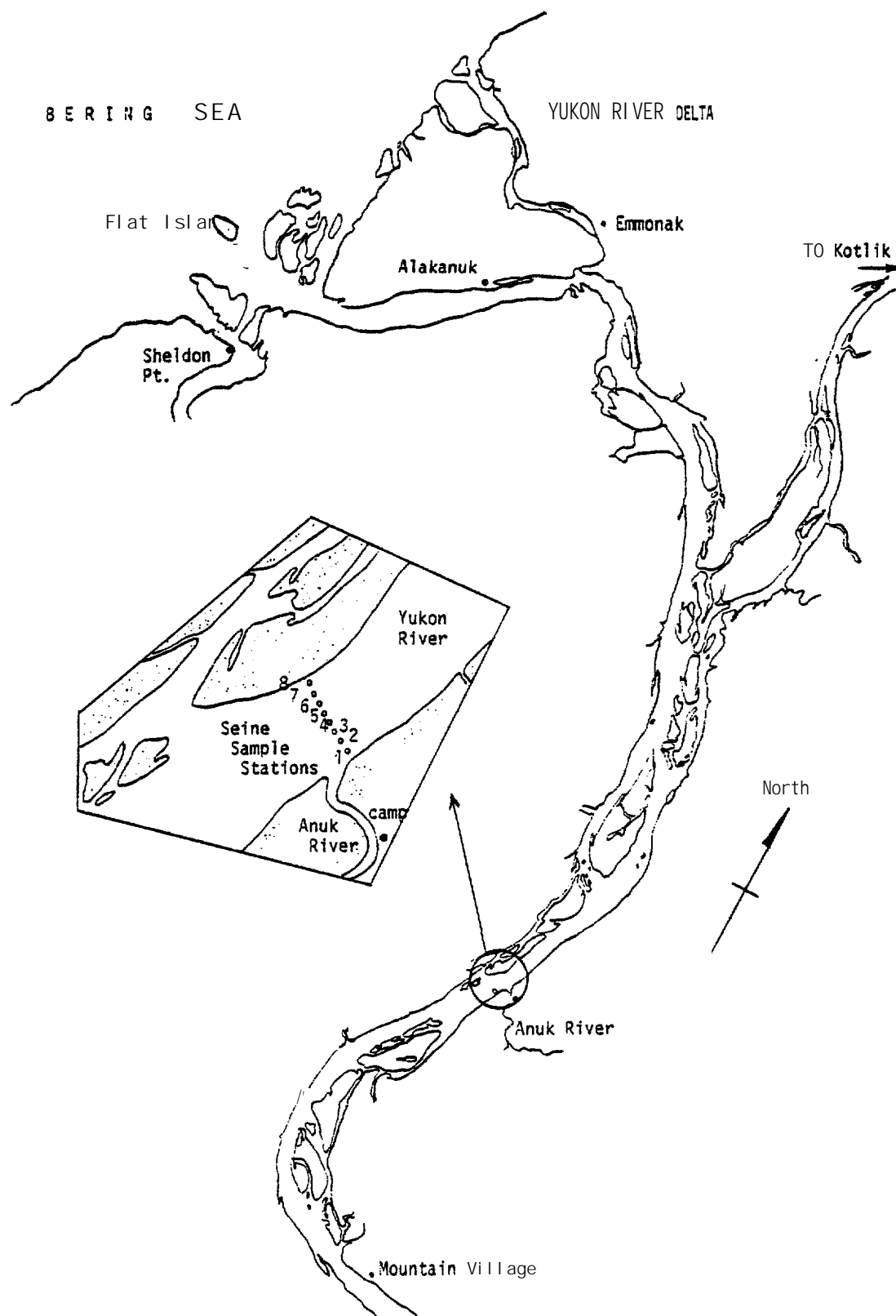


Figure 2. Yukon River smelting site June 7 through July 7, 1977. Site was located 101 kilometers upriver from Flat Island at the confluence of the Anuk River.

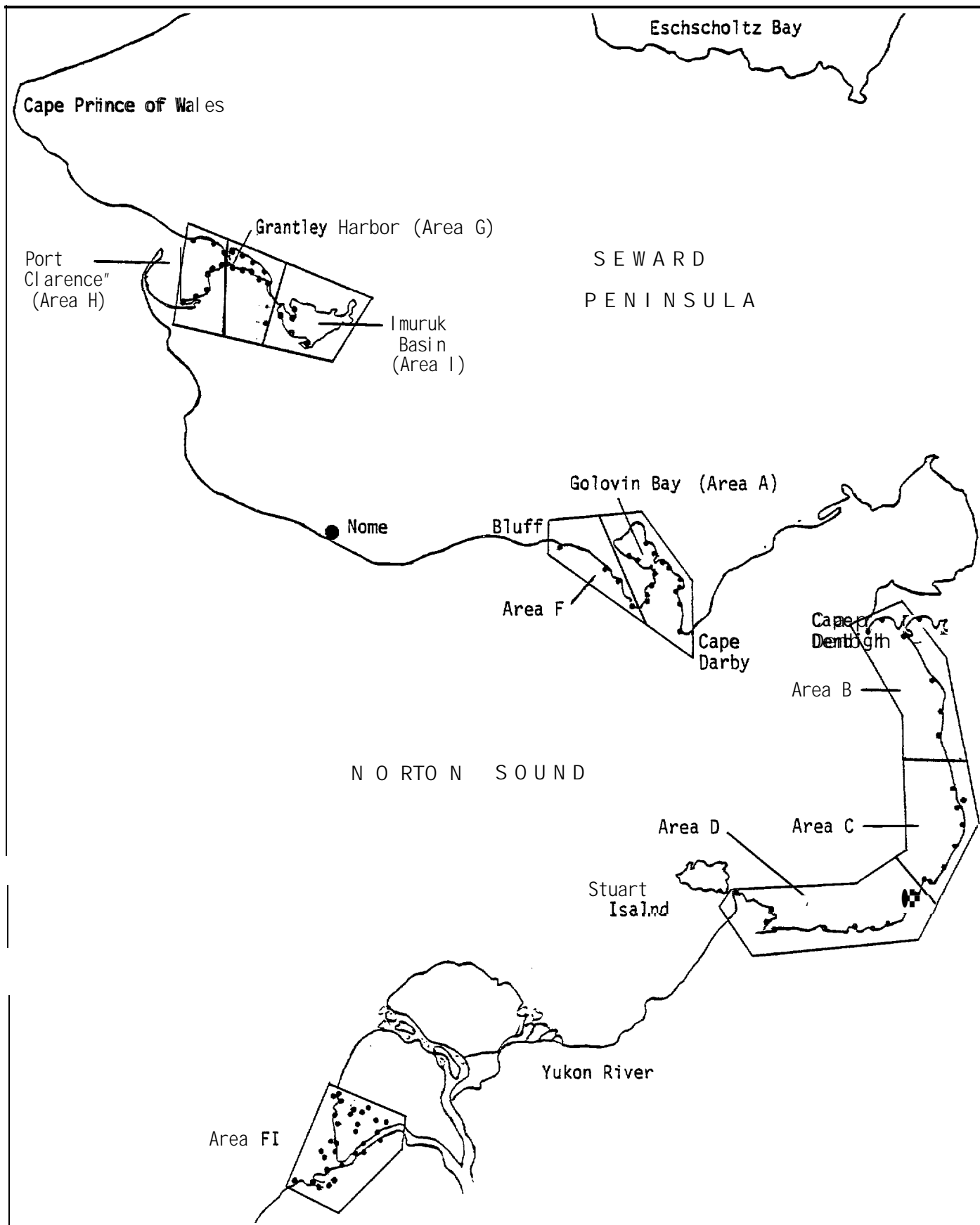


Figure 3. Sample locations for nearshore studies conducted under R.U. 19 throughout Norton Sound and the Yukon River Delta, 1976-77.

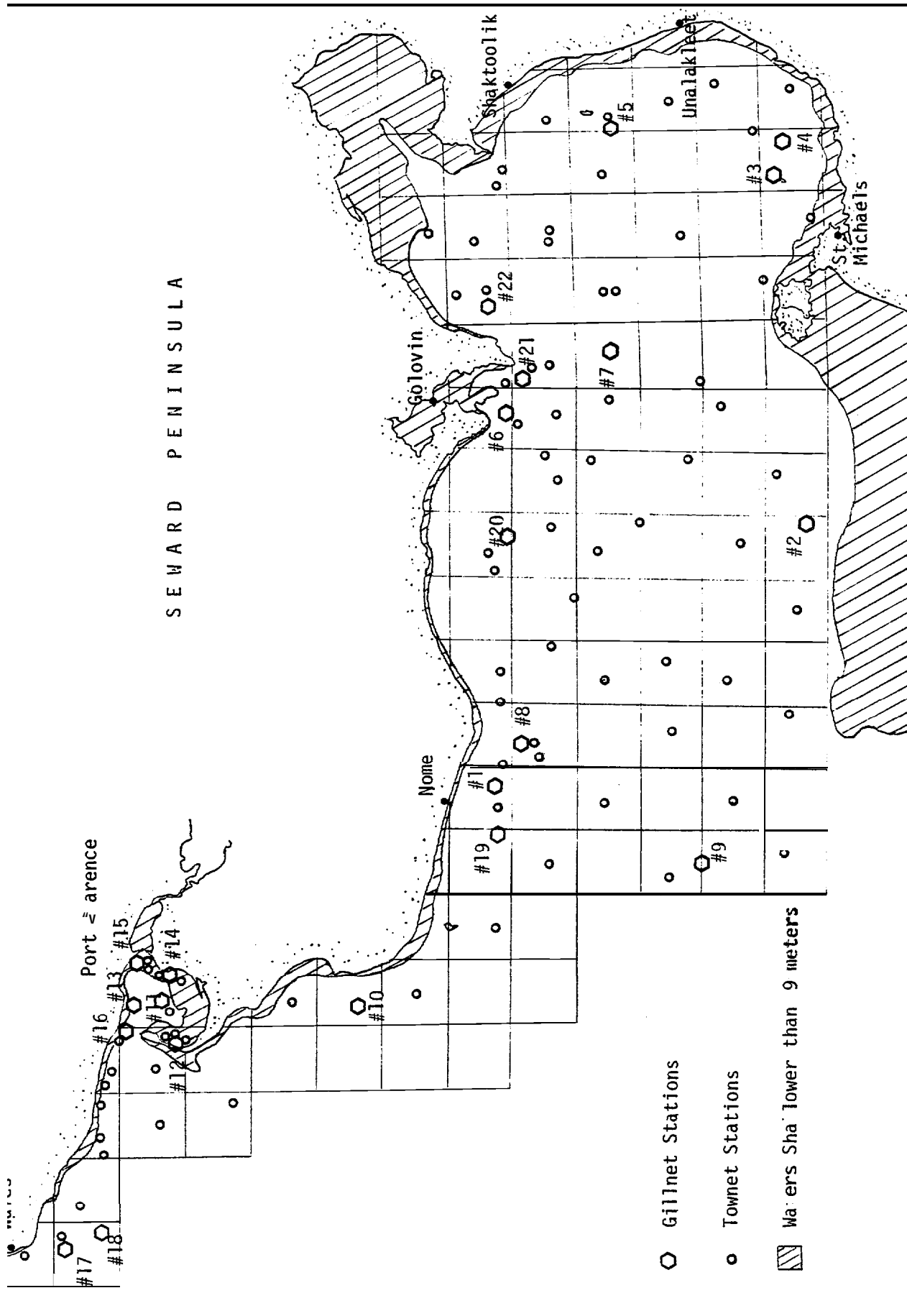


Figure 4. Surface townet and gill net sample stations from June 22 through July 12 in Norton Sound, 1977.

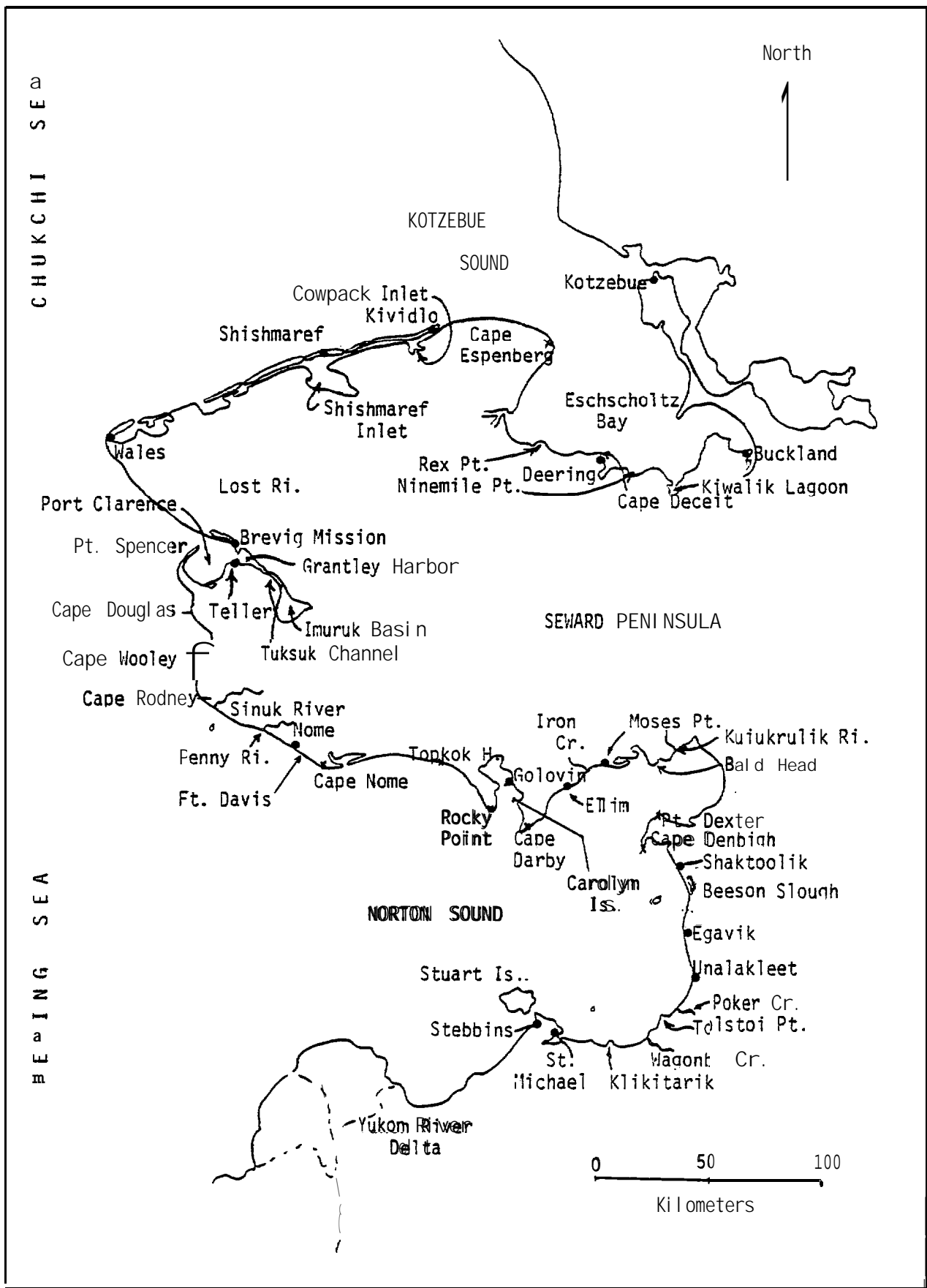
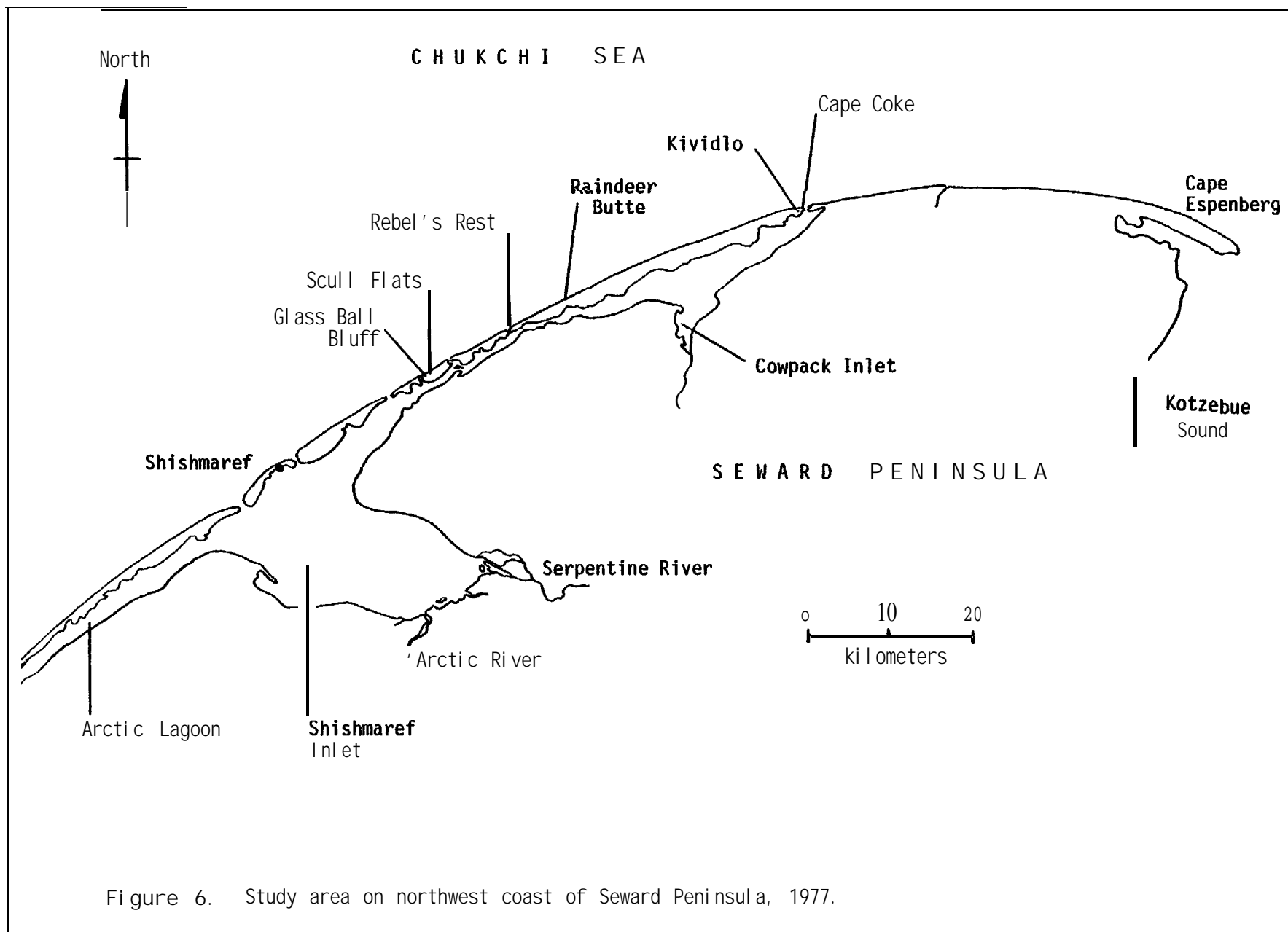


Figure 5. Study area for aerial herring surveys.



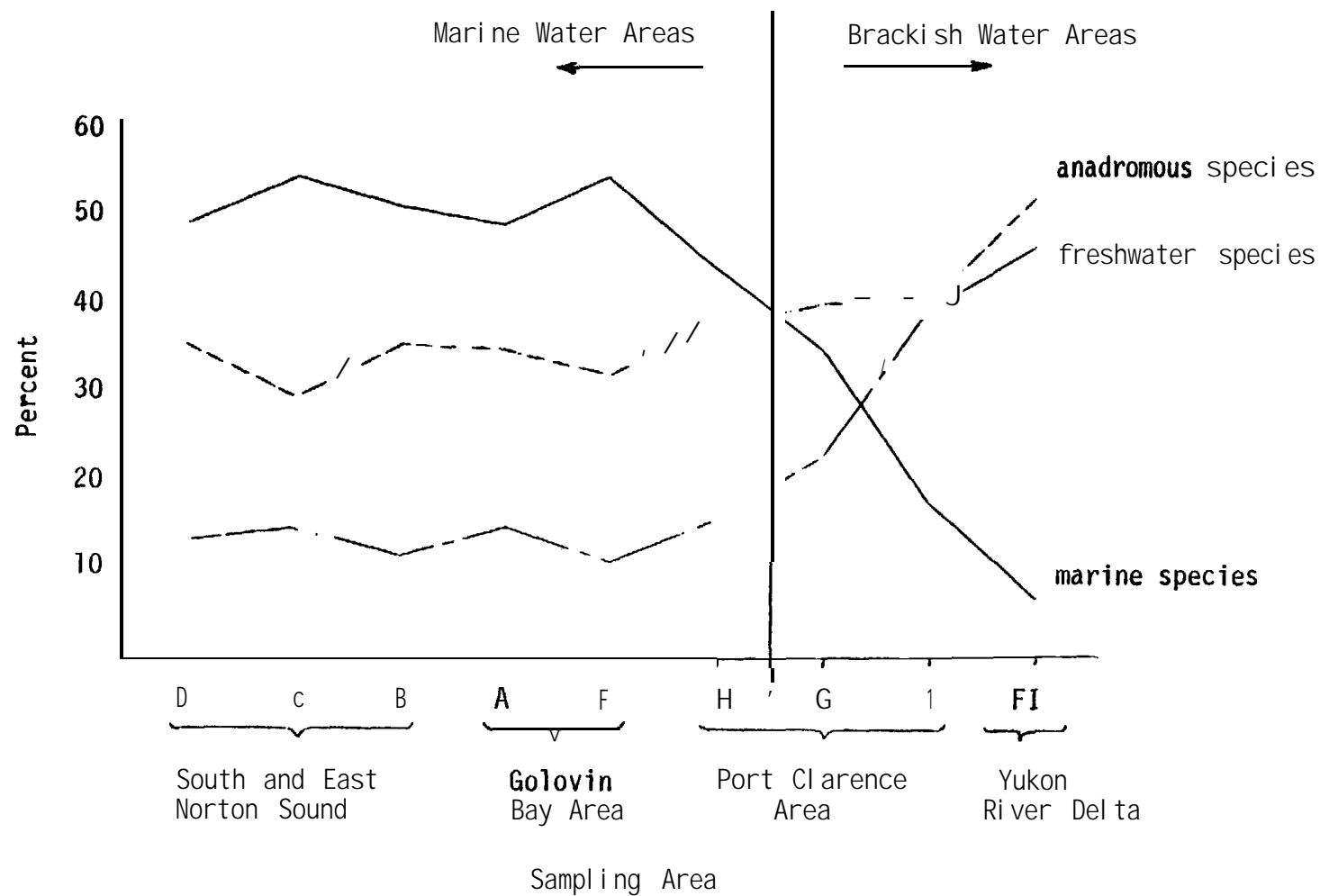


Figure 7 Species diversification by area of **finfish** captured in the coastal waters of Norton Sound from the Yukon River Delta to Port Clarence, 1976-77.

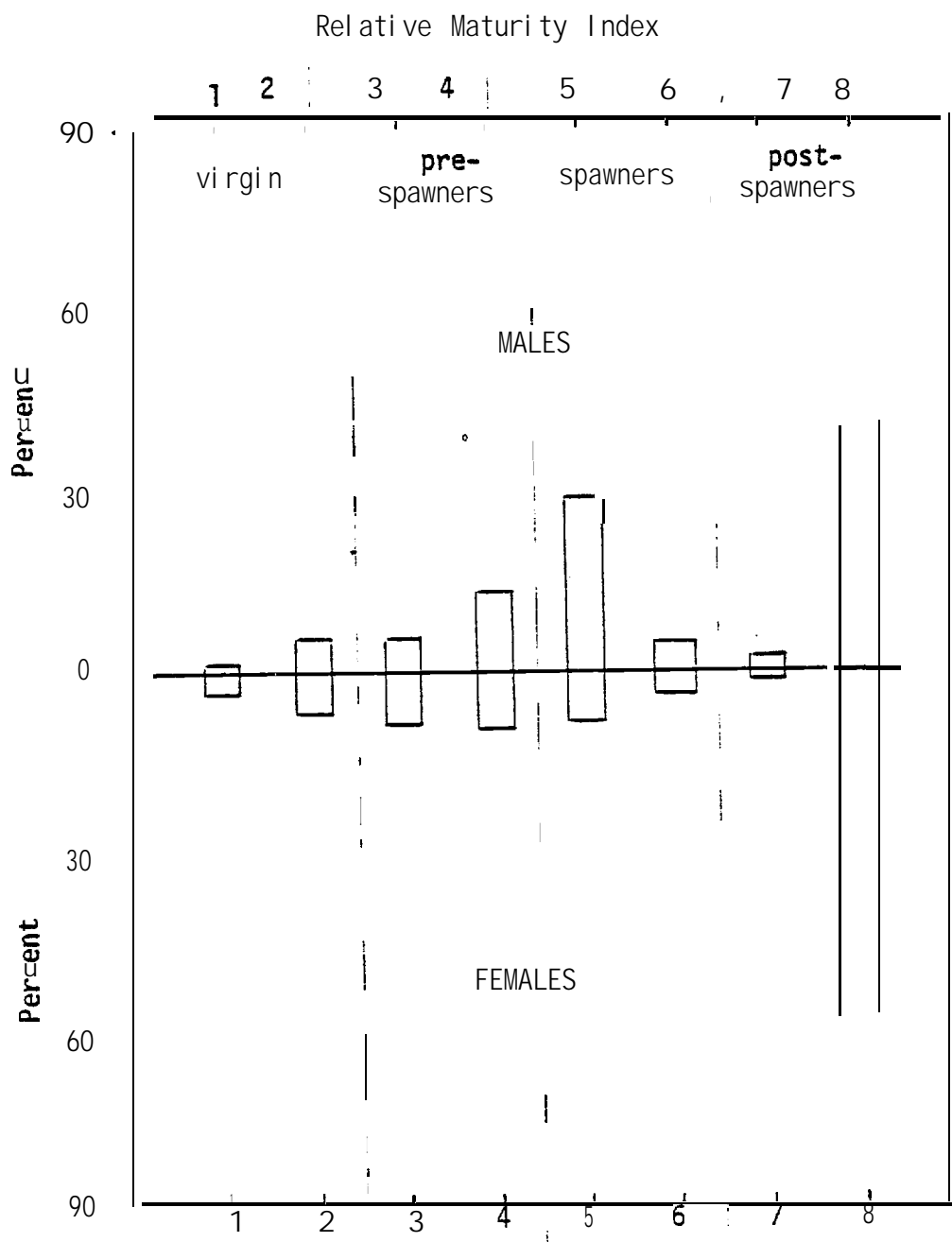


Figure 8 . Relative maturity by sex of herring captured in the Port Clarence area from ice breakup (late June) through freezeup (late October), 1977.

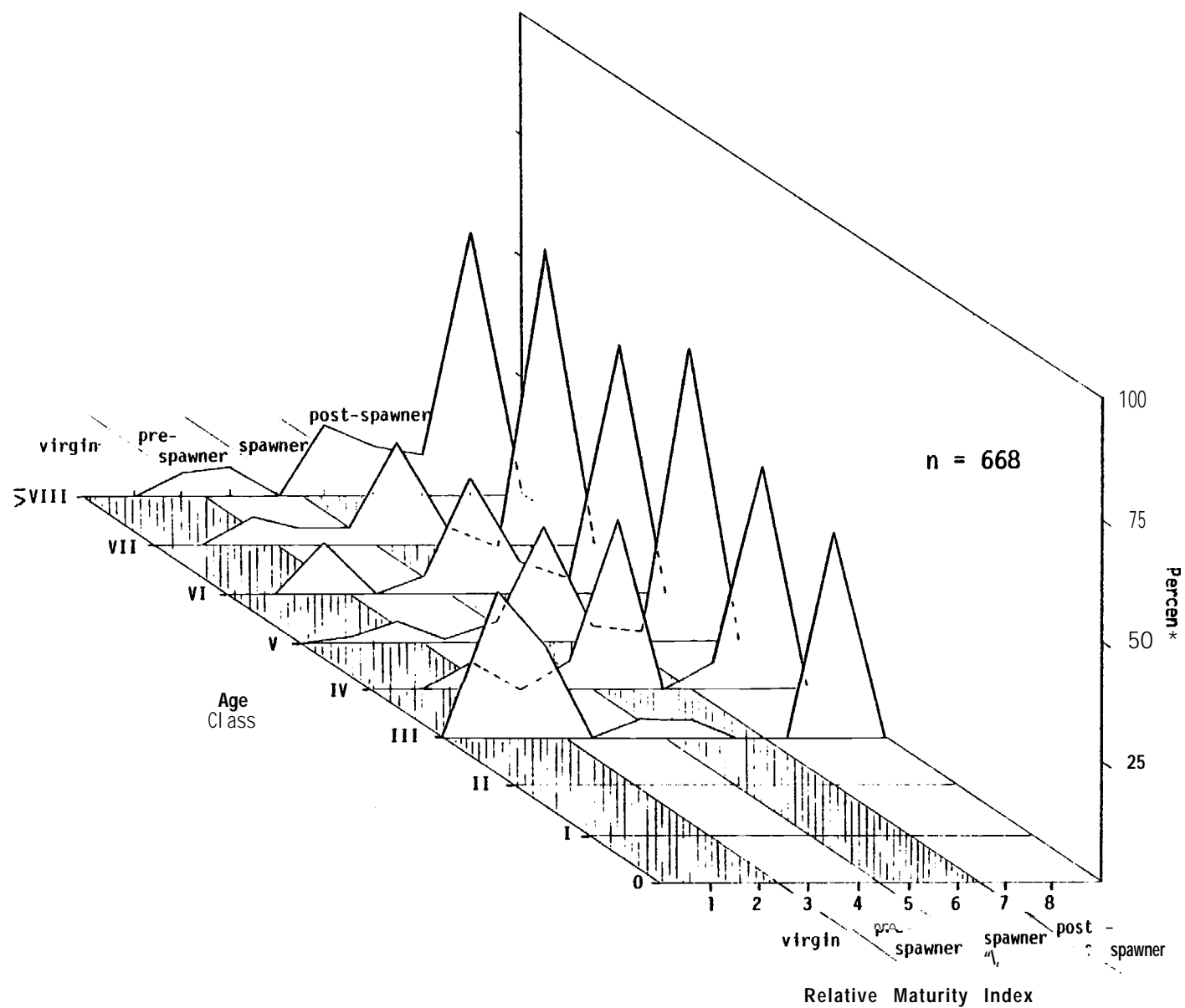


Figure 9. Relative maturity by age of herring captured in the Port Clarence area from ice breakup (late June) through July 21, 1977.

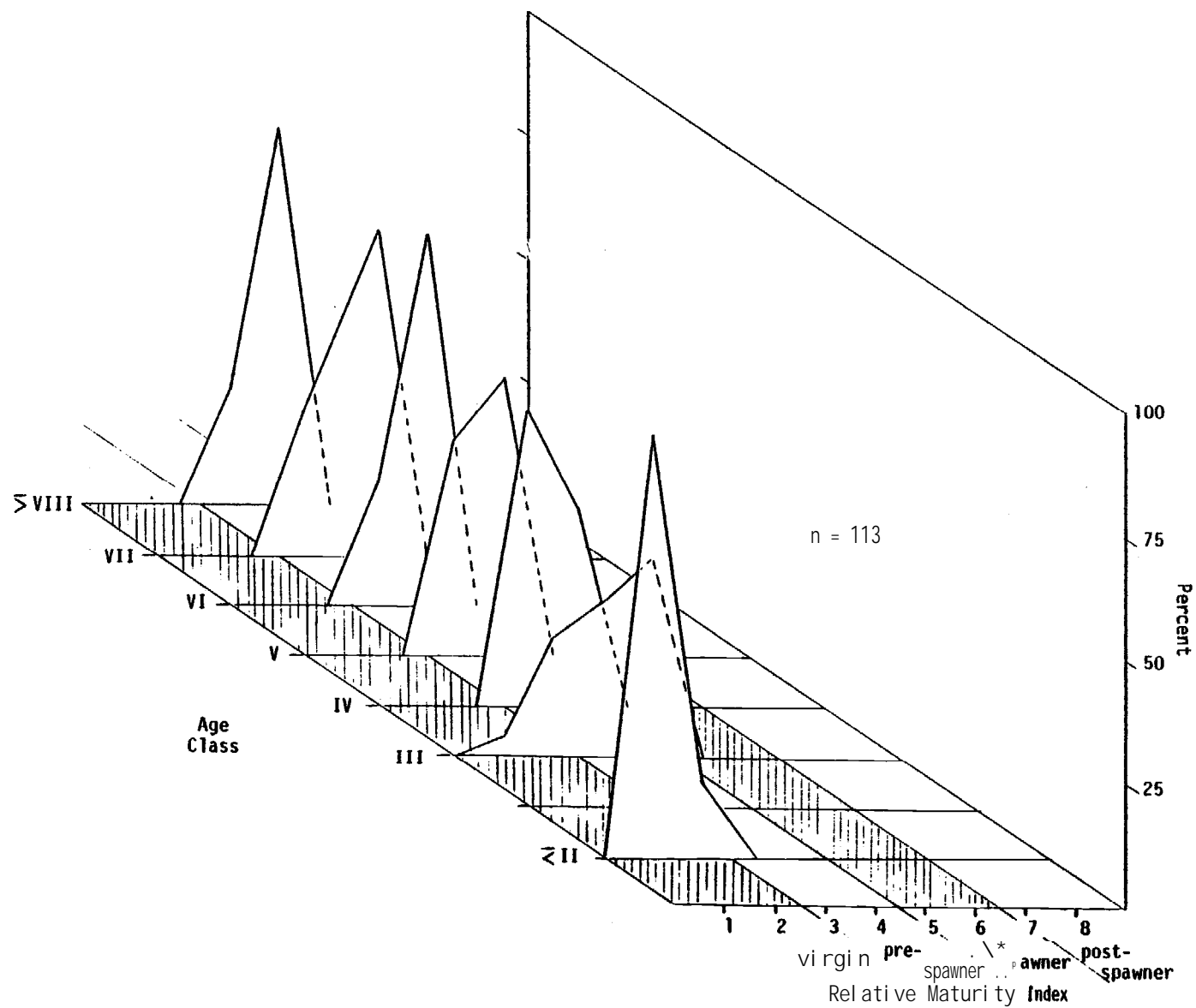


Figure 10. Relative maturity by age of herring captured in the Port Clarence area from September 7 through freezeup (late October), 1977.

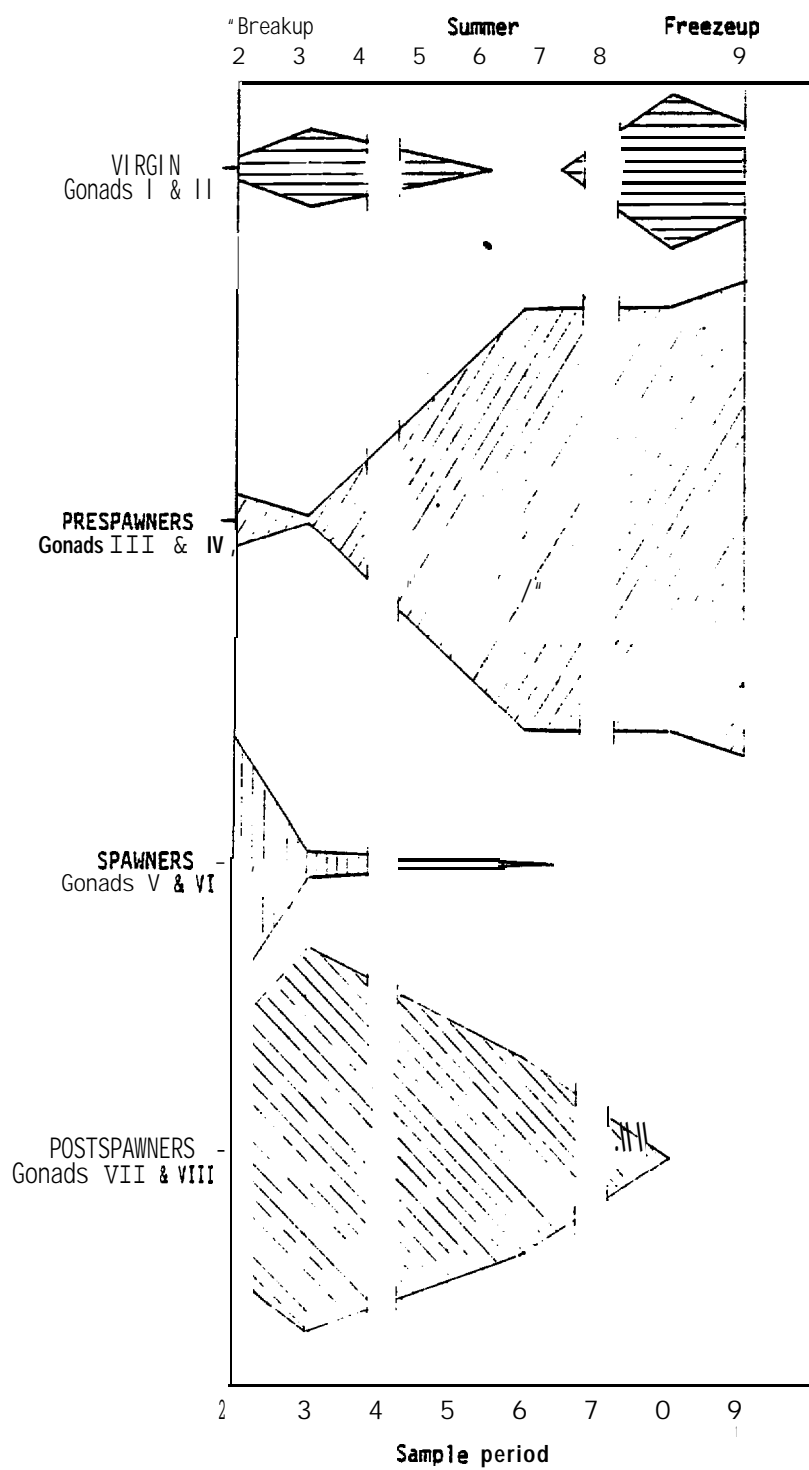


Figure 11. Relative maturity of **herring** captured in the Port Clarence area from ice breakup (late June) through freezeup (late October), 1977.

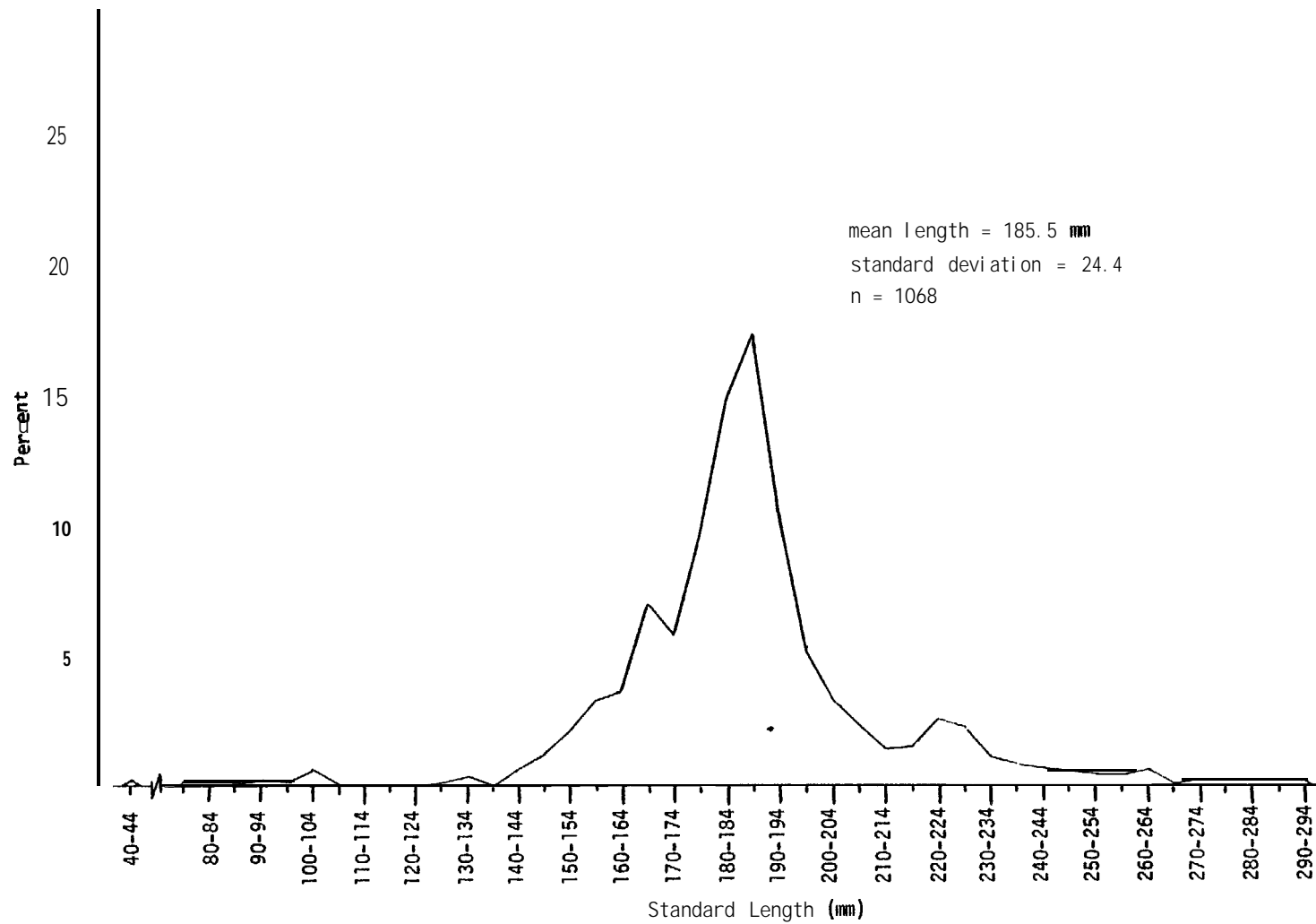


Figure 12. Length frequency (percent) of herring captured in the Port Clarence area from ice breakup (late June) through freezeup (late October), 1977.

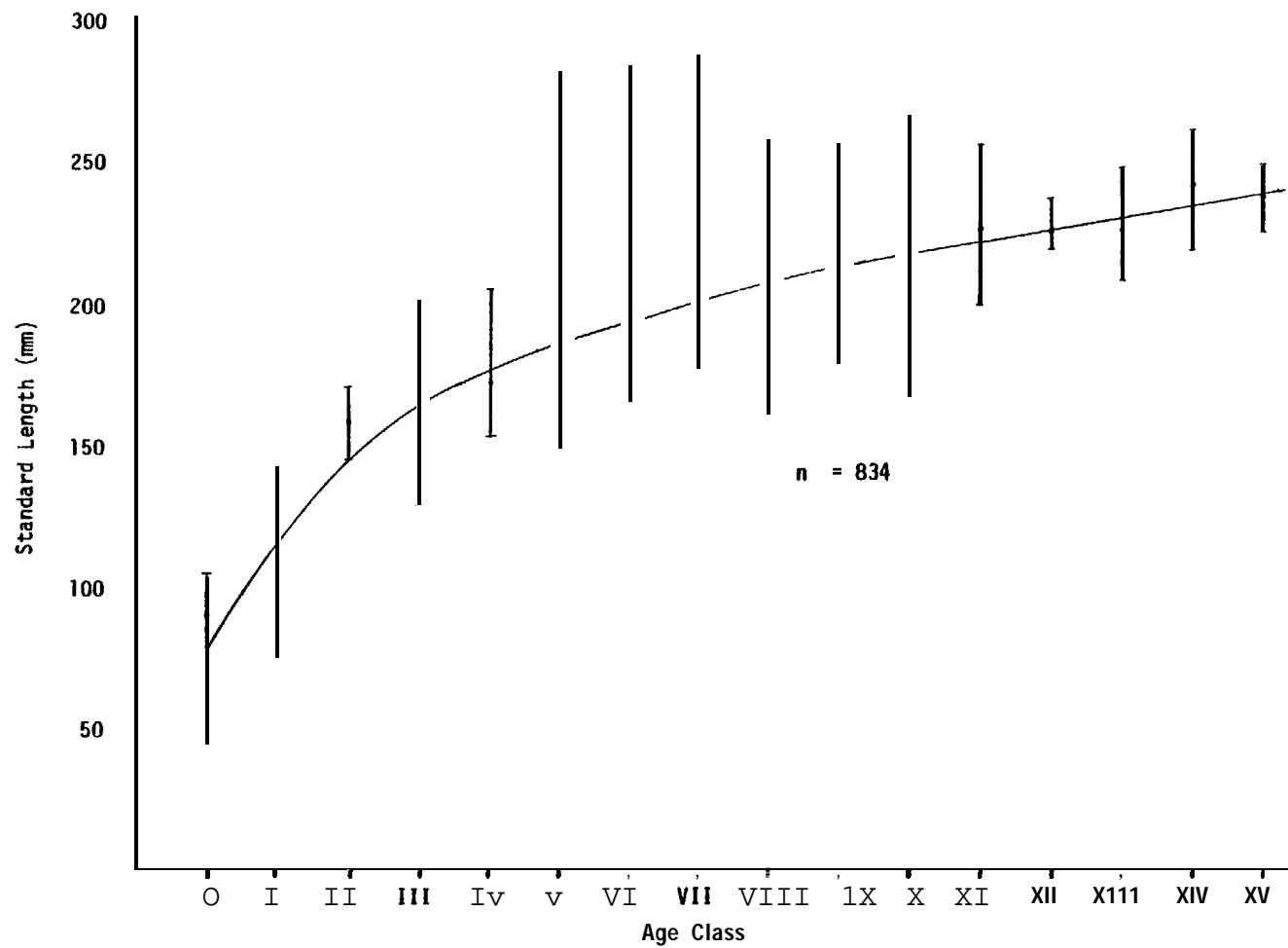


Figure 13. Mean length-at-age (shown with ranges) for herring captured in the Port Clarence area, 1977.

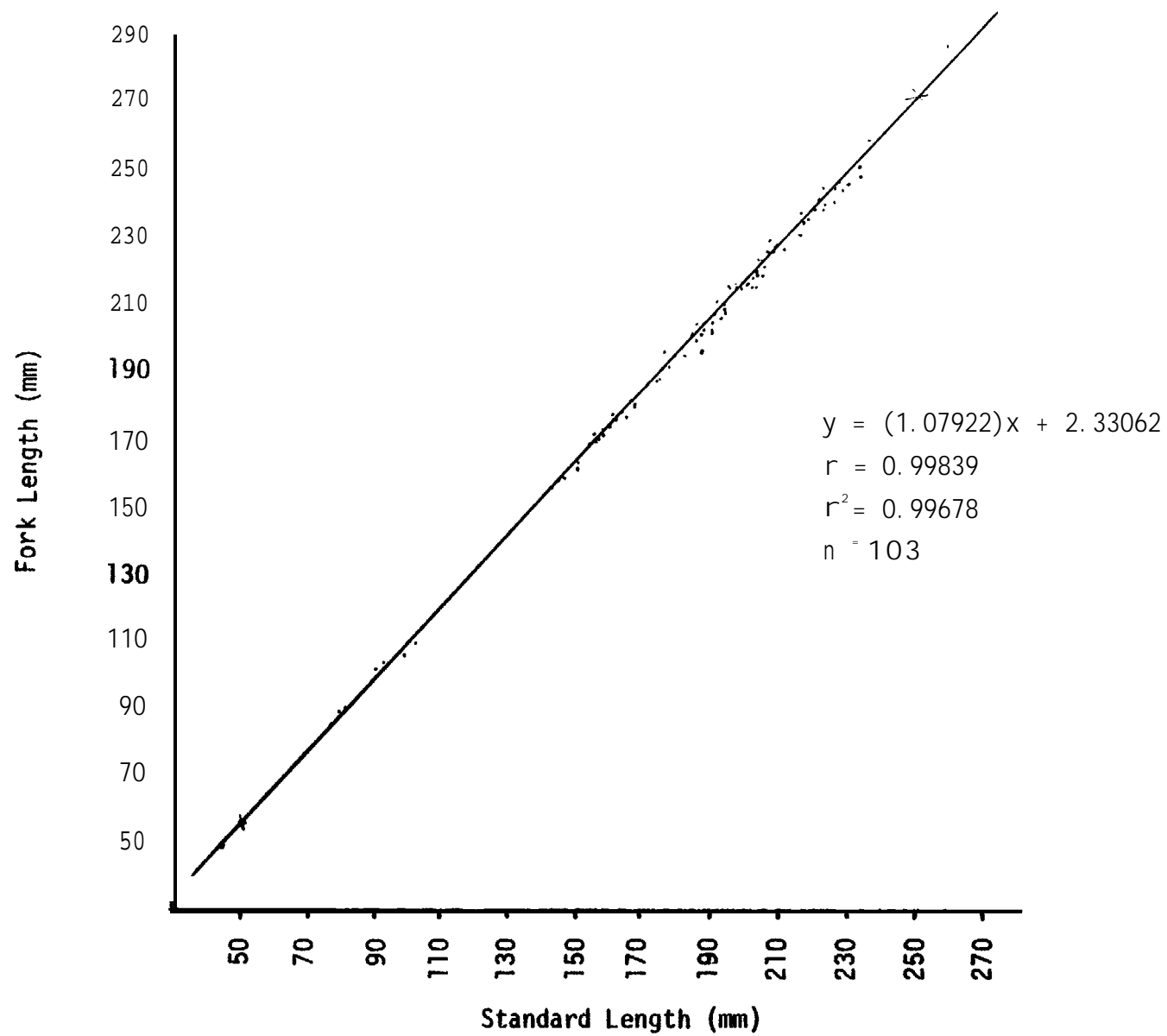


Figure 15. Relationship between fork length and standard length of Pacific herring captured in Port Clarence June through October, 1977.

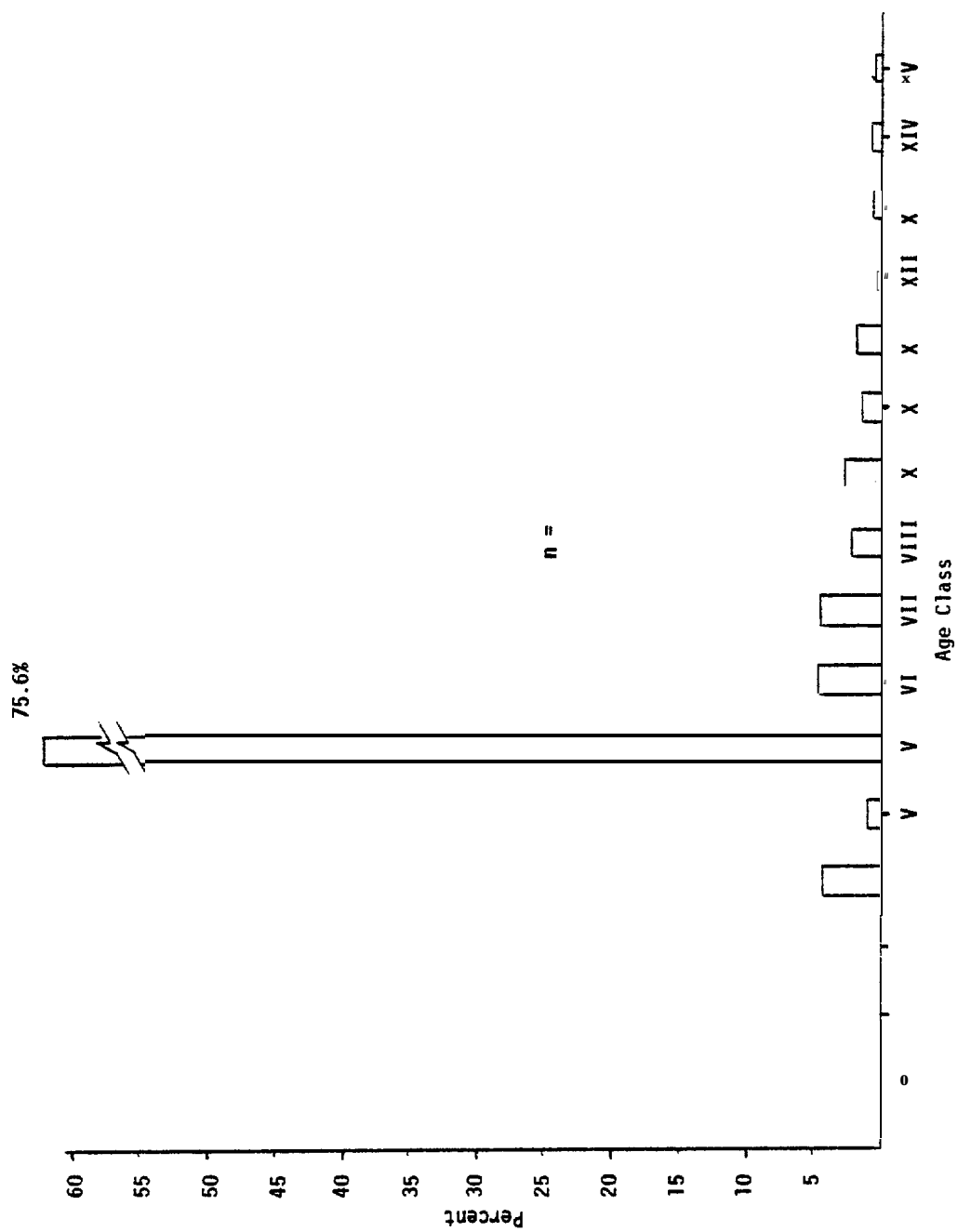


Figure 16. Percent age composition of herring captured in the Port Clarence area from ice breakup to July 21, 1977.

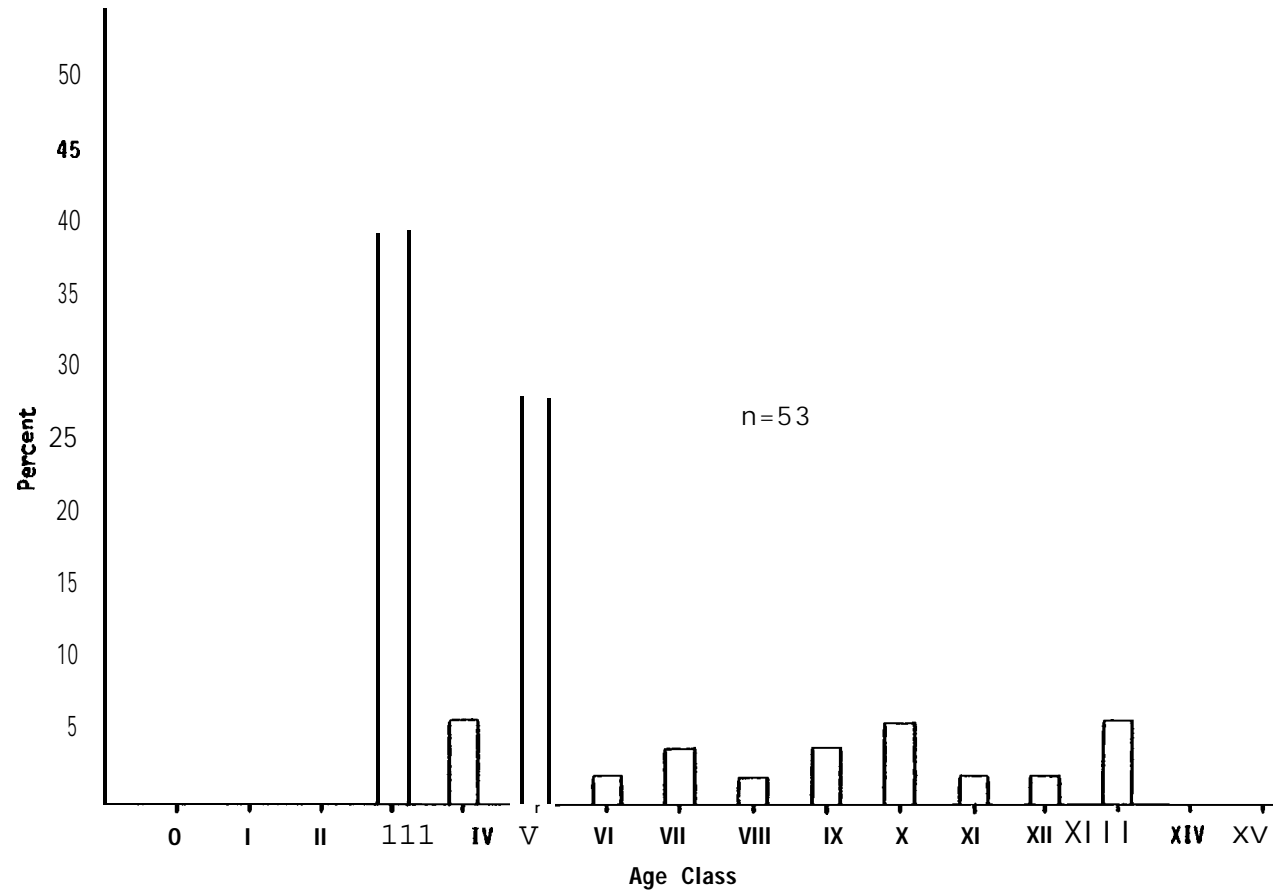


Figure 17. Percent age composition of herring captured in the Port Clarence area from July 22 through September 6, 1977.

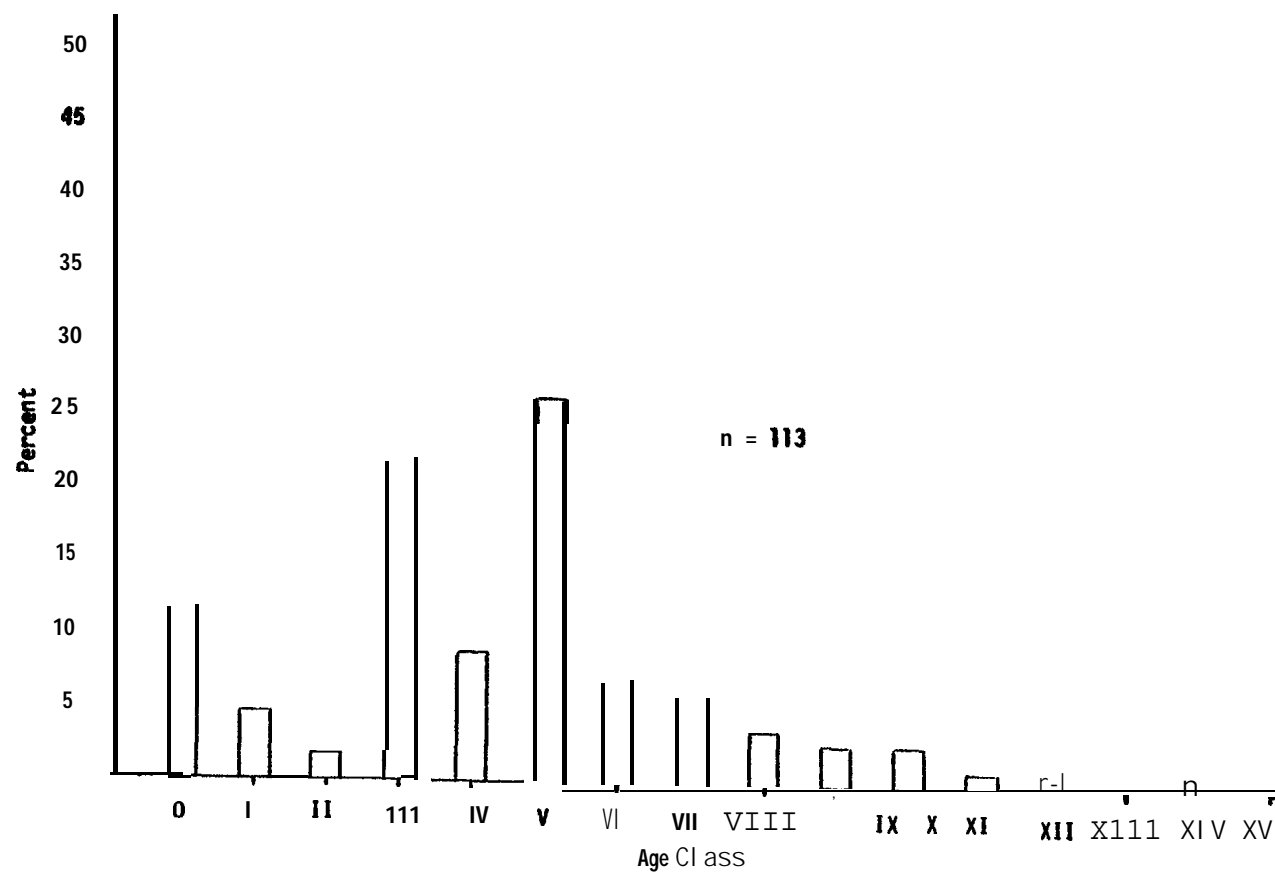


Figure 18. Percent age composition of herring captured in the Port Clarence area from September 7 through freezeup, 1977.

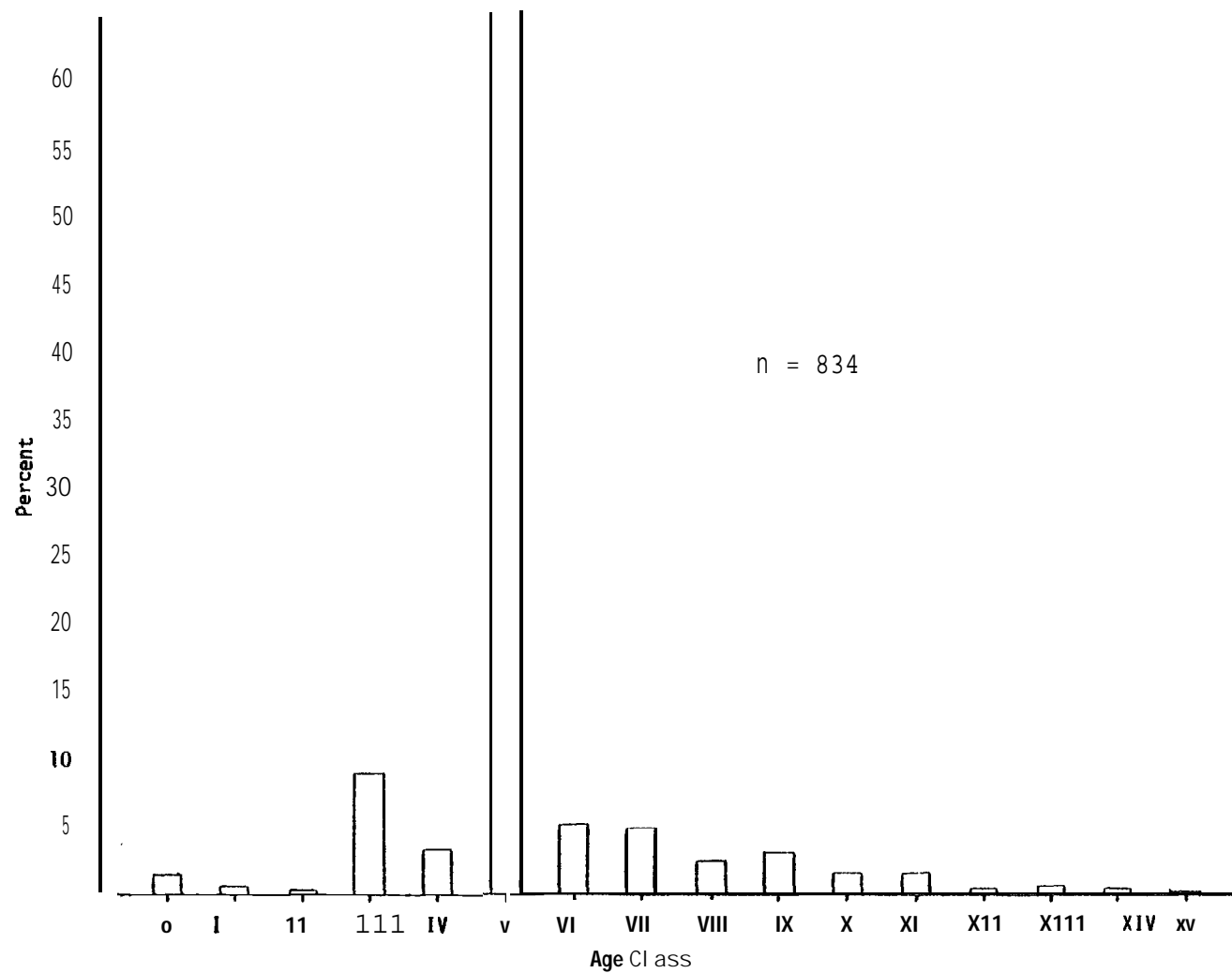


Figure 19. Percent age composition of herring captured in the Port Clarence area from ice breakup (late June) through freezeup (late October), 1977.

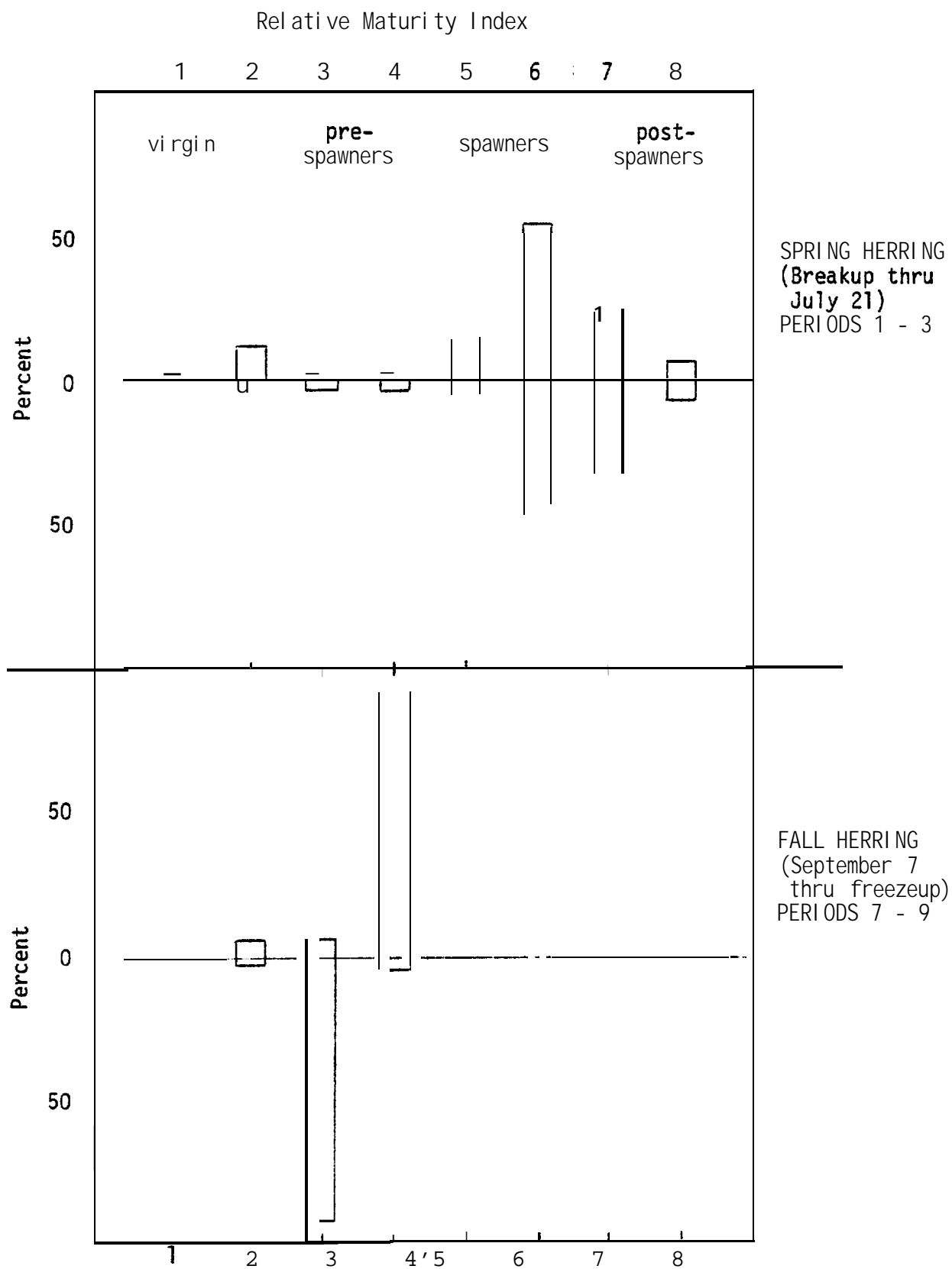


Figure 20. Comparison of the relative maturity of spring and fall herring captured in Golovin Bay 1977.

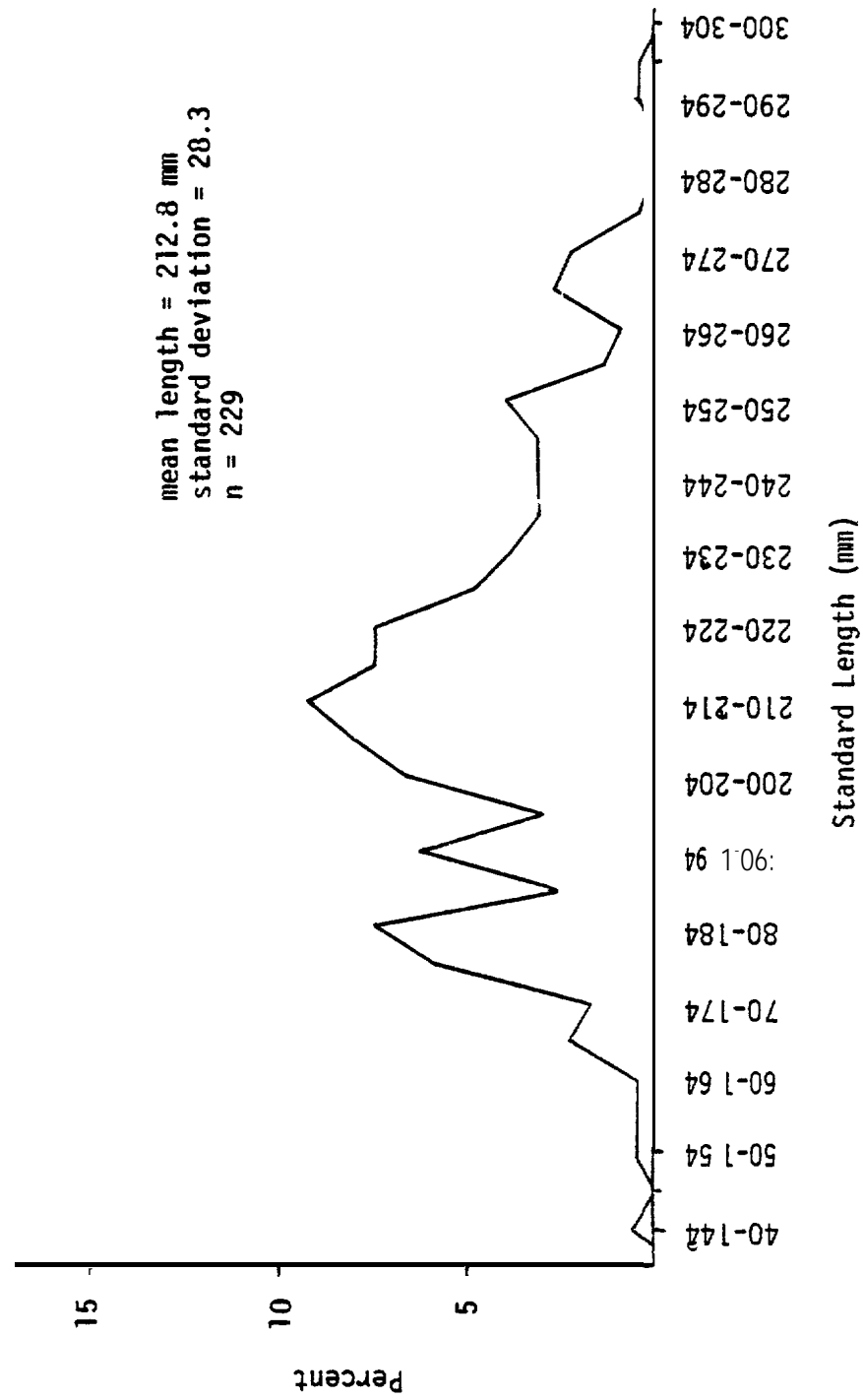


Figure 21. Length frequency (percent) of herring captured in Golovin Bay from ice breakup (June) through freezeup (October), 1977.

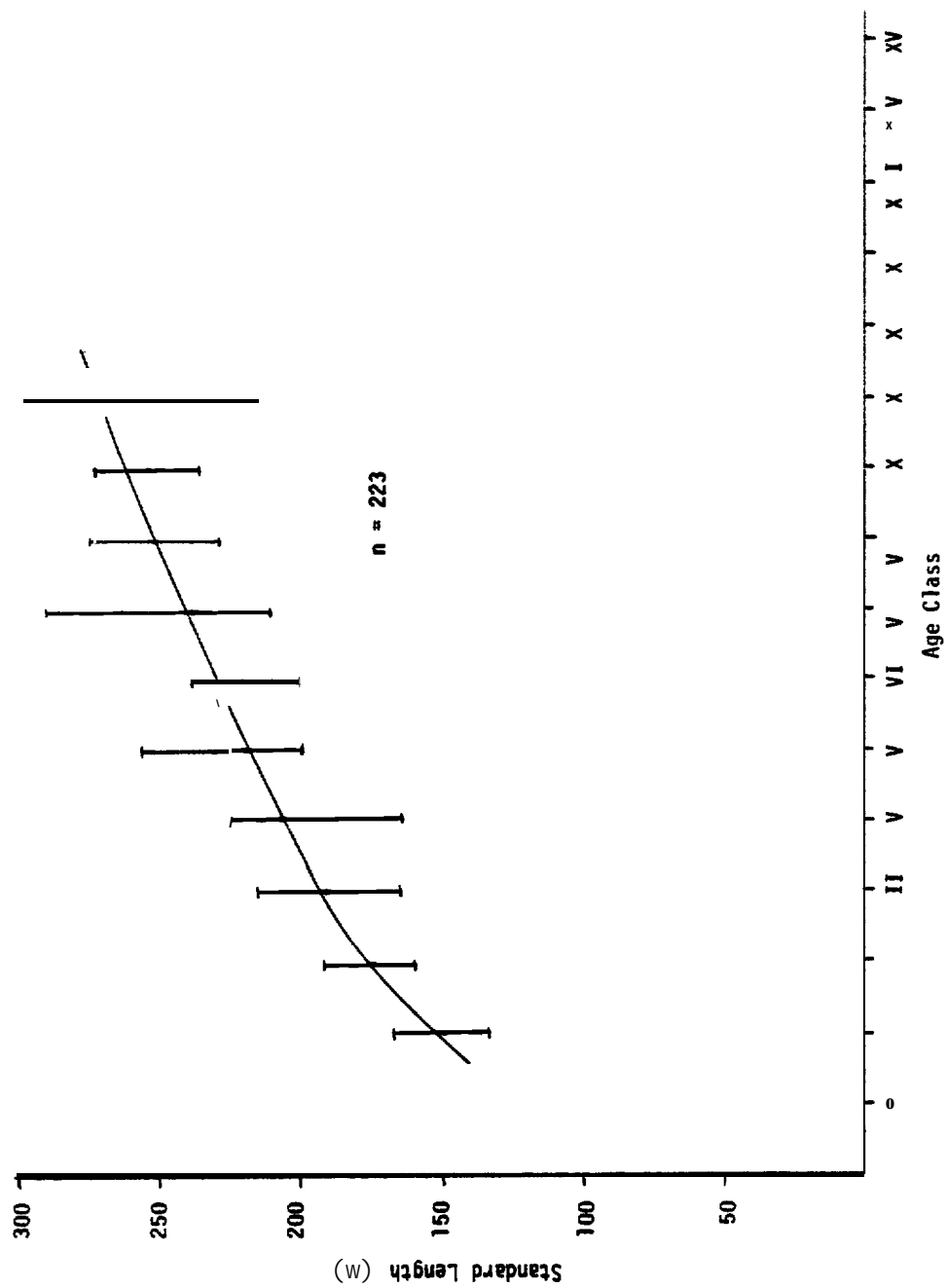


Figure 22. Mean length-at-age (shown with ranges) for herring captured in Golovin Bay, 1977.

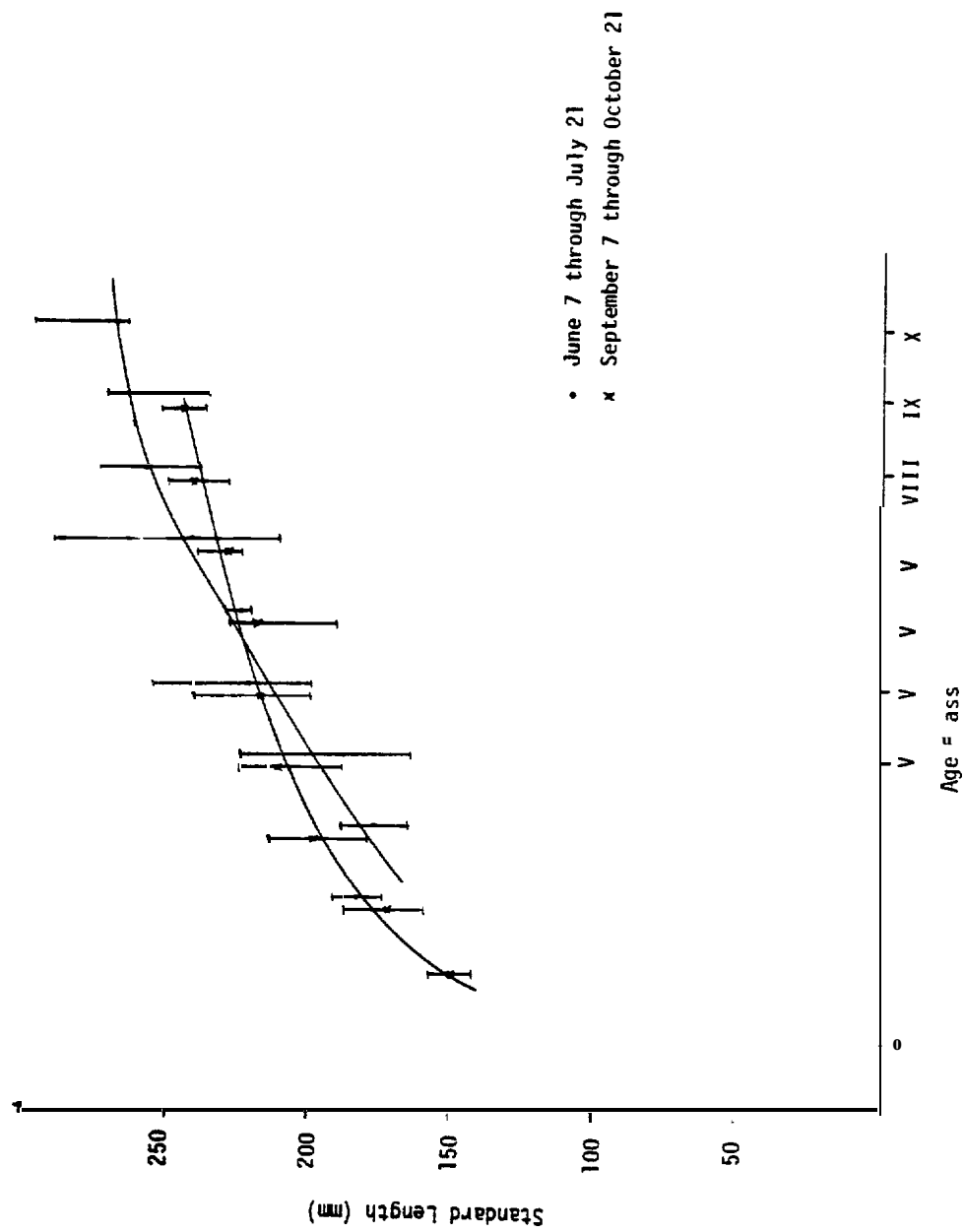


Figure 23. Mean length-at-age for herring captured in the spring (June 7 - July 21) and fall (September 7 - October 21) in Golovin Bay, 1977. Mean lengths are shown with ranges.

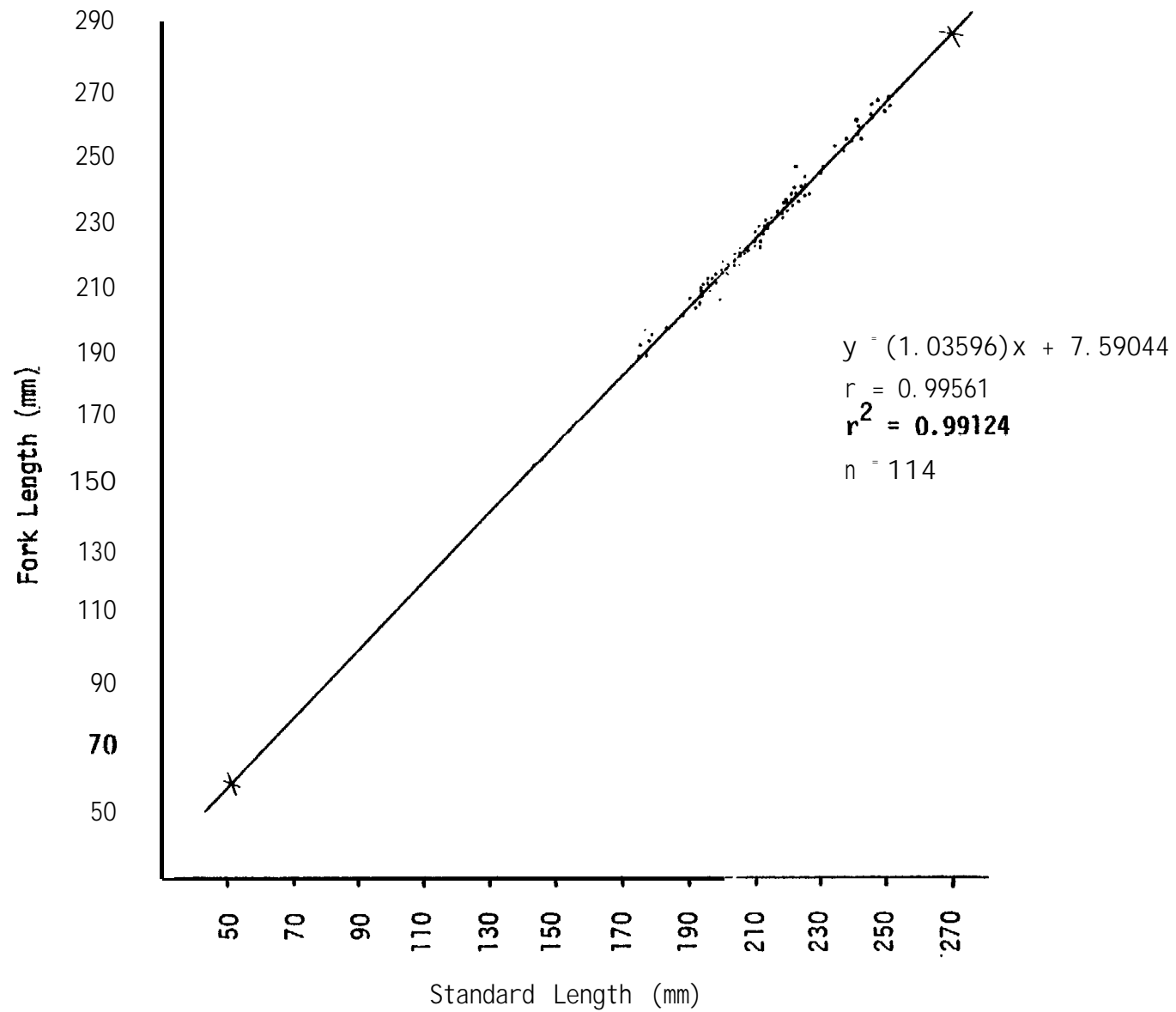


Figure 24. Relationship between fork length and standard length of Pacific herring captured in Golovin Bay June through October, 1977.

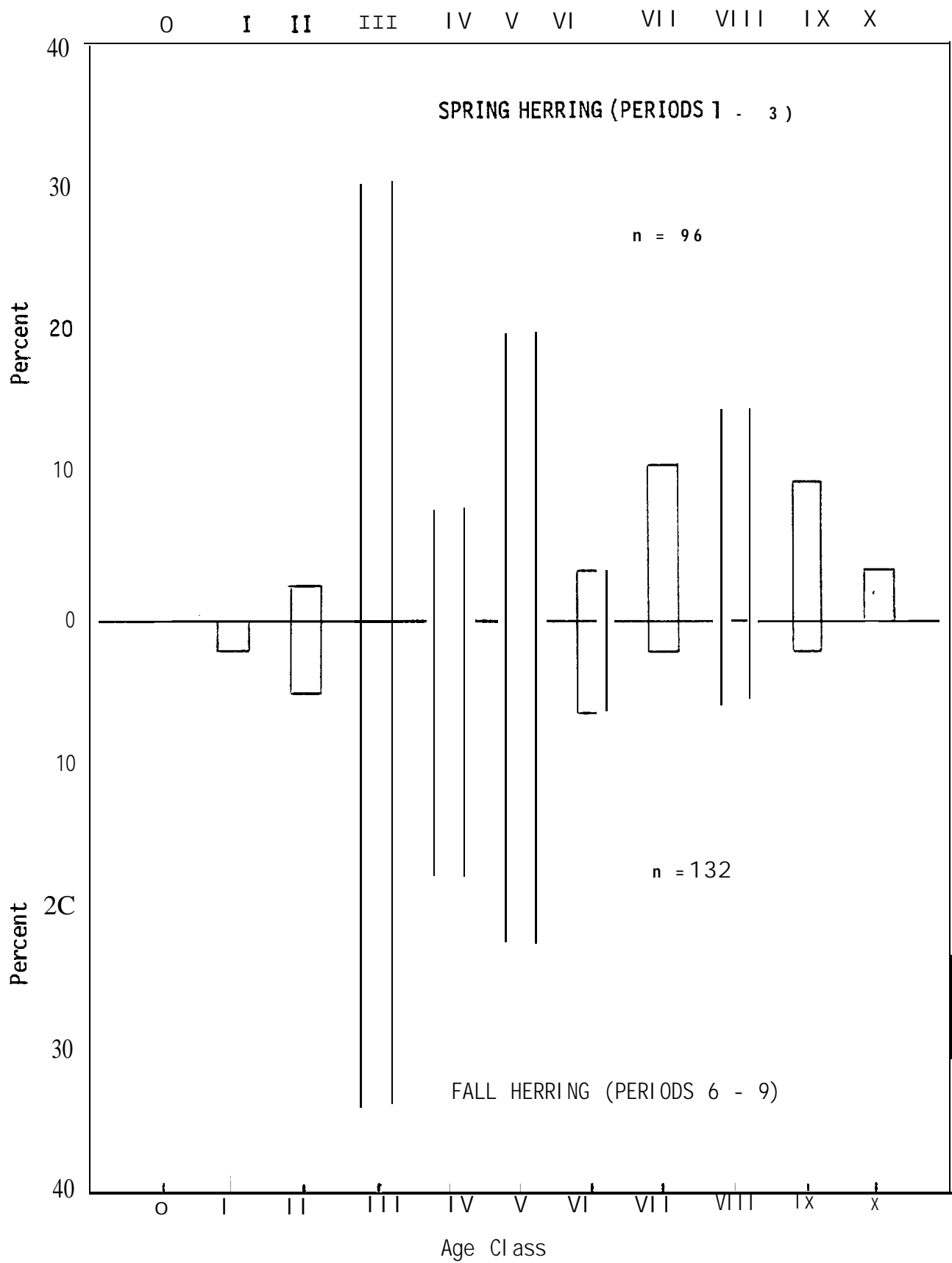


Figure 25. Comparison of percent age composition between spring and fall herring populations in Golovin Bay, 1977.

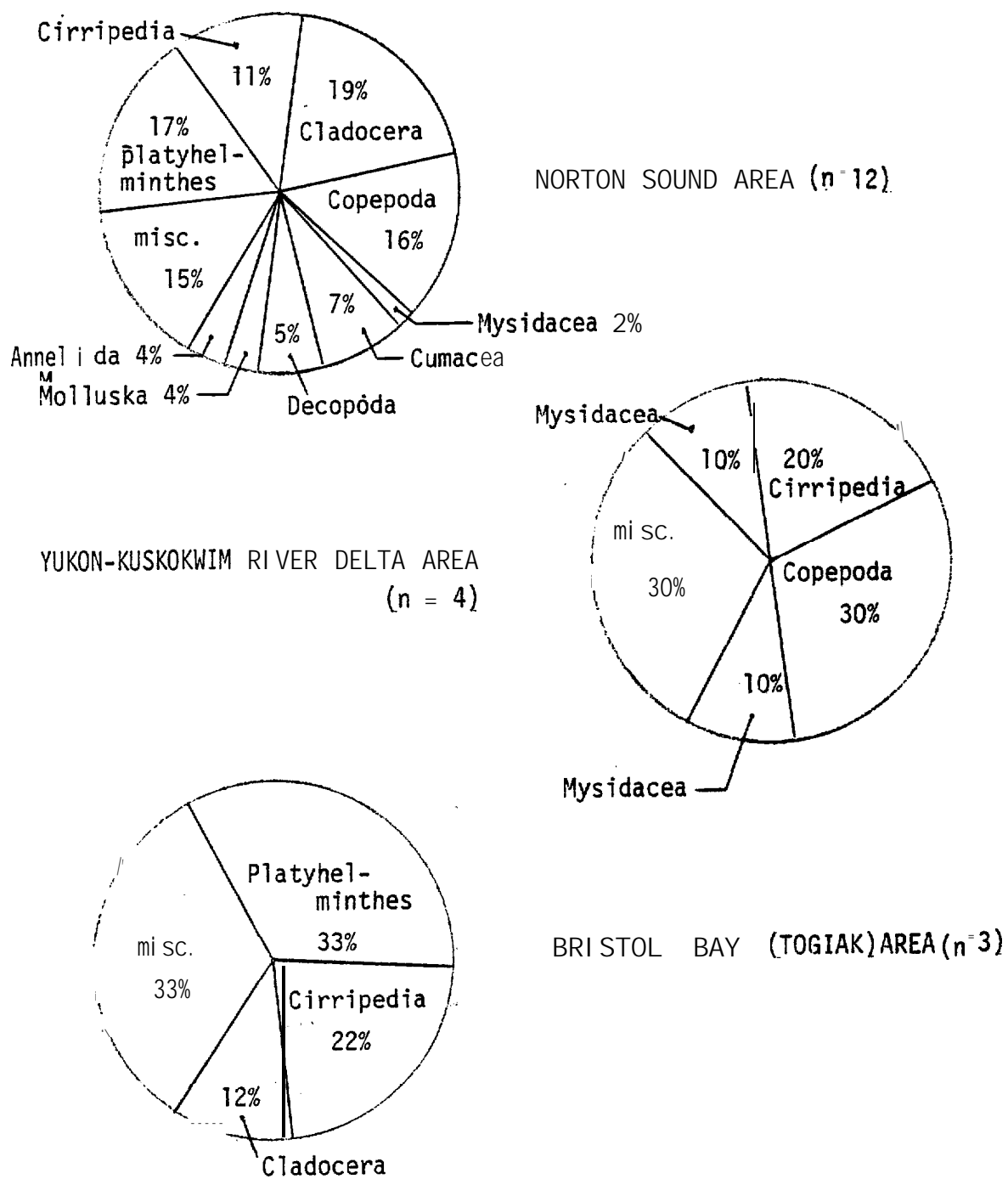


Figure 26. Percent occurrence of the total number of food items in herring stomachs examined along the western Alaska coastline, 1976.

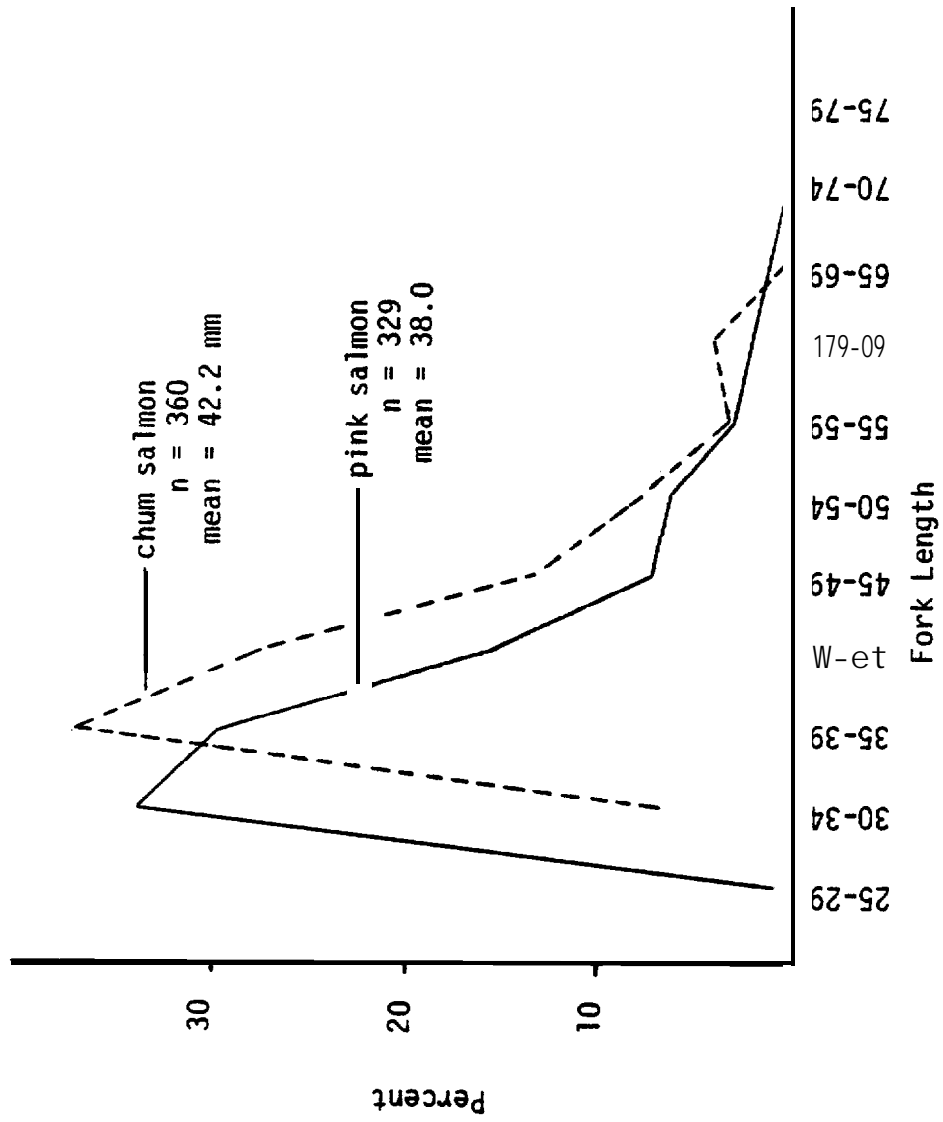


Figure 27. Length frequency (percent) of juvenile pink and chum salmon captured in Golovin Bay June 9 through July 9, 1977.

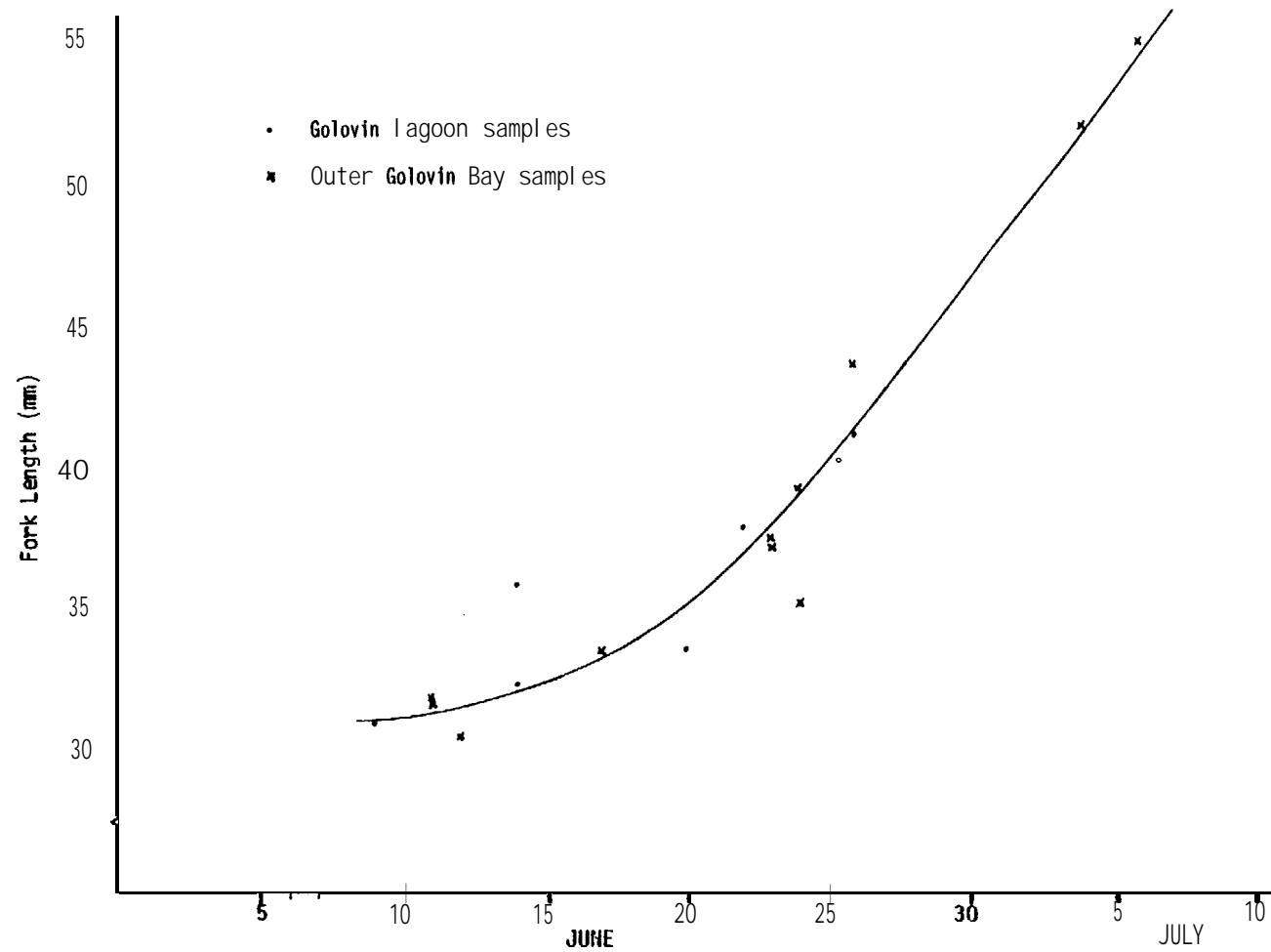


Figure 28. Growth of juvenile pink salmon captured in the nearshore waters of Golovin Bay from June 9 through July 9, 1977.

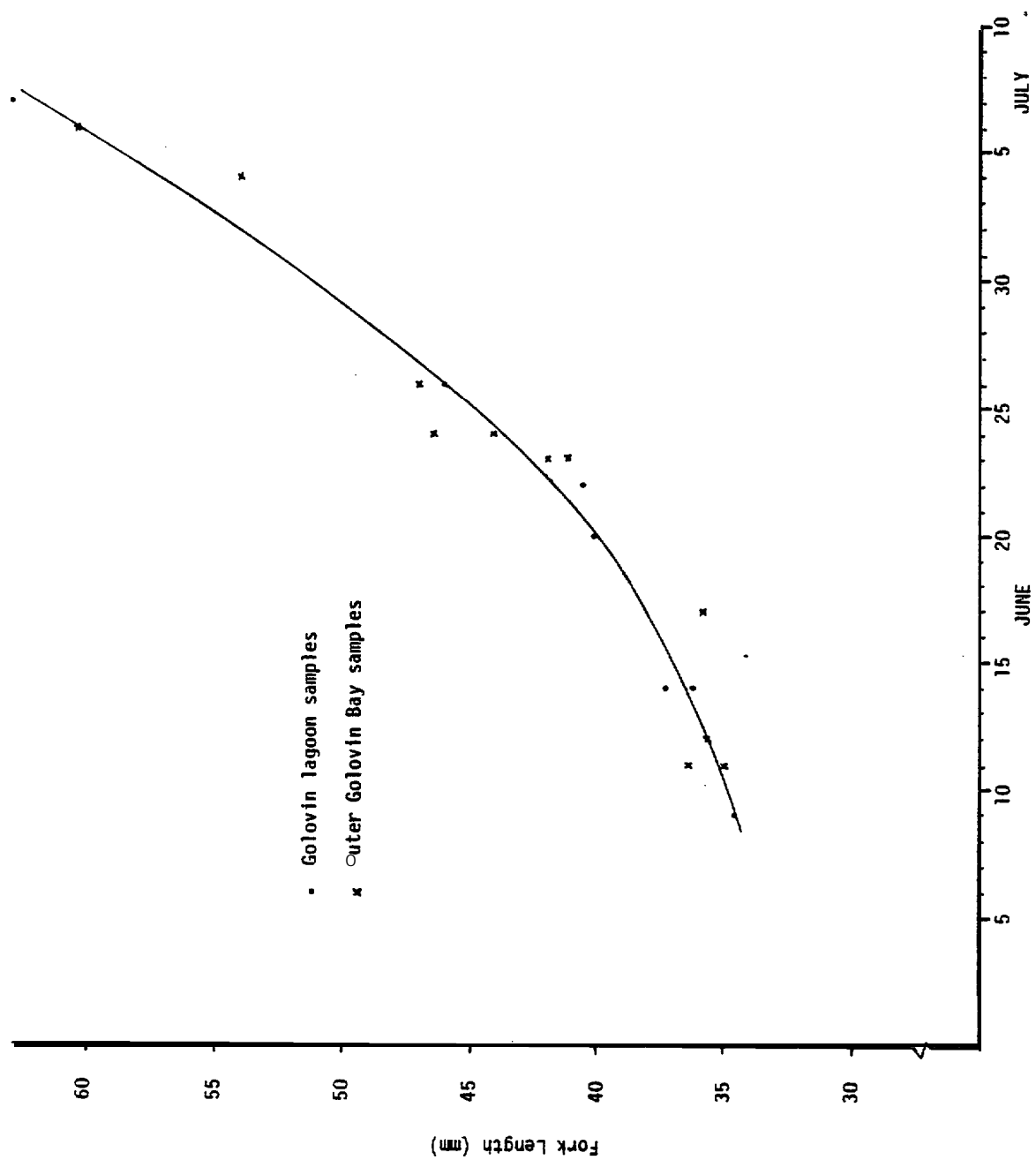


Figure 29. Growth of juvenile chum salmon captured in the nearshore waters of Golovin Bay from June 9 through July 9, 1977.

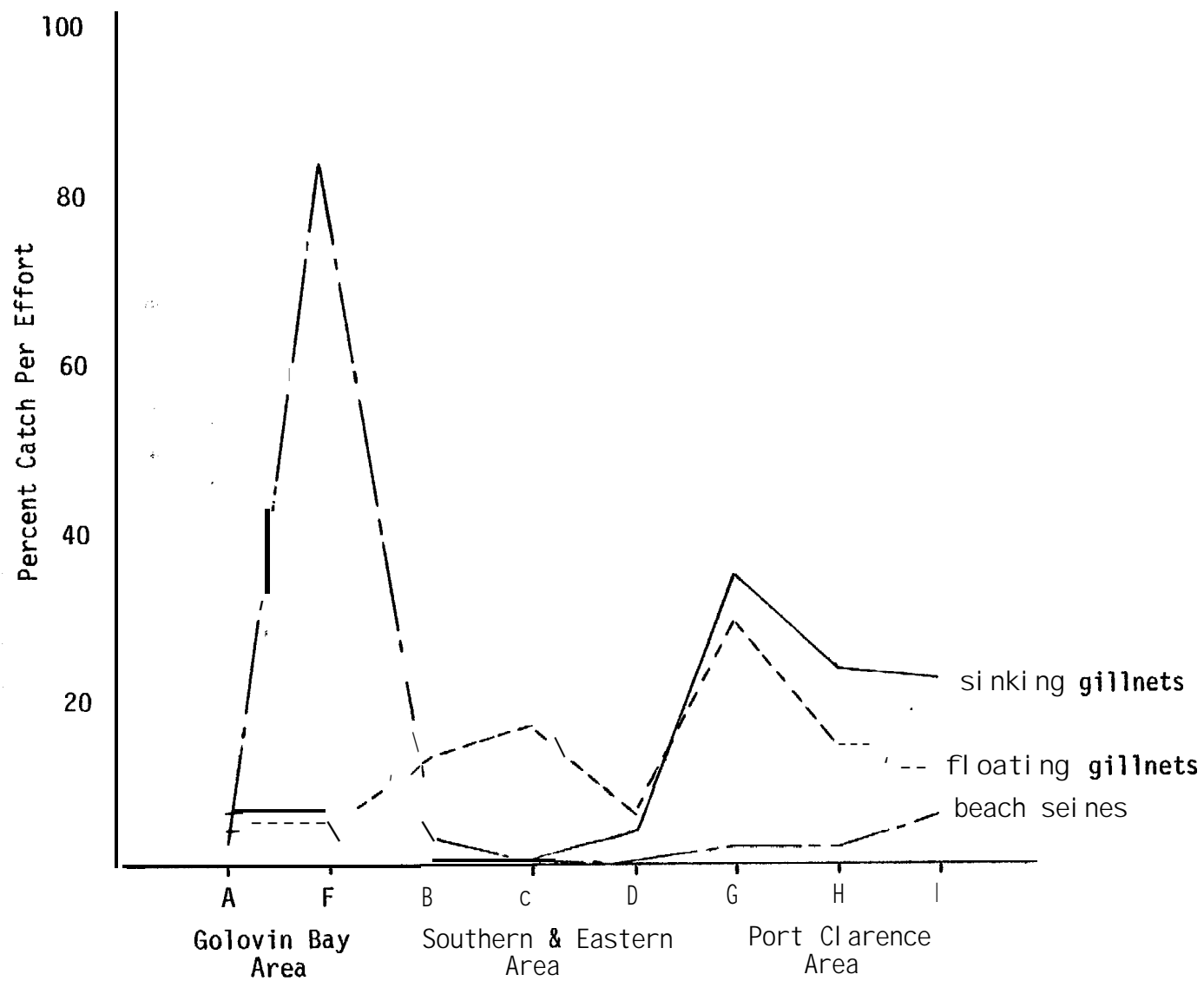


Figure 30. Percent catch per effort for finfish captured in the nearshore waters of Norton Sound from June 7 through October 21, 1977.

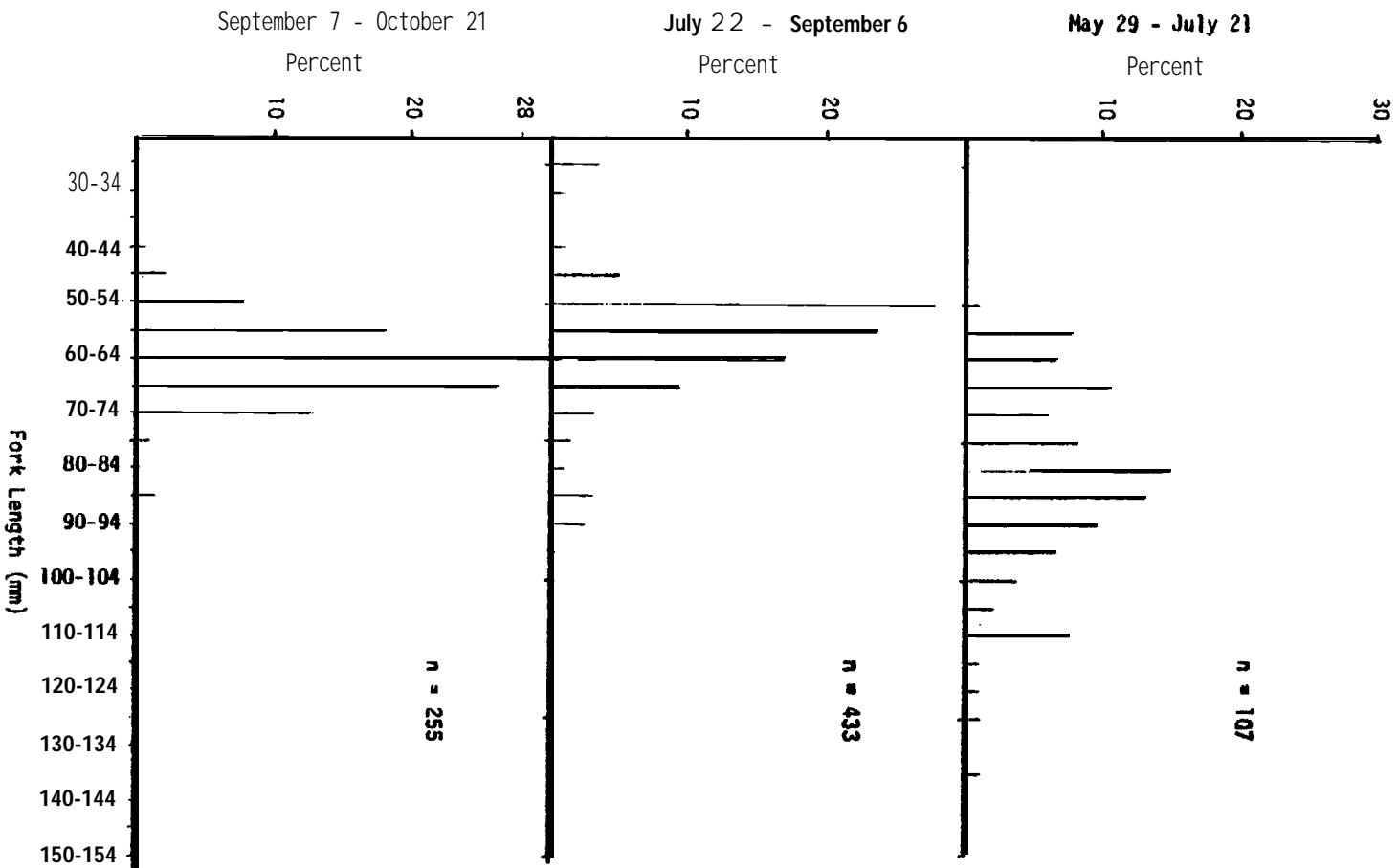


Figure 3 Length frequency (percent) of sand lance captured in Golovin Bay, 1977.

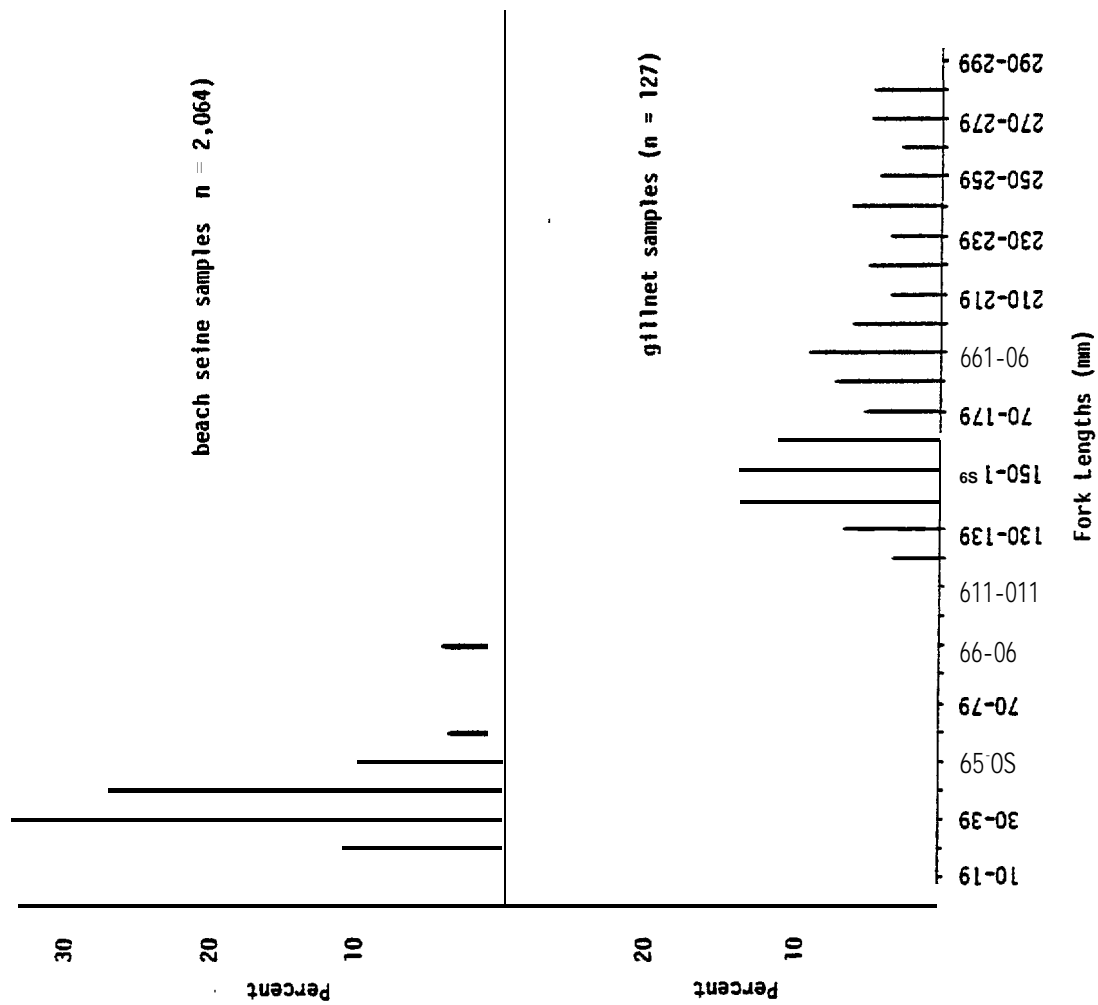


Figure 32. Length frequency (percent) of boreal smelt by gear type captured in nearshore waters of Norton Sound from June through October, 1977.

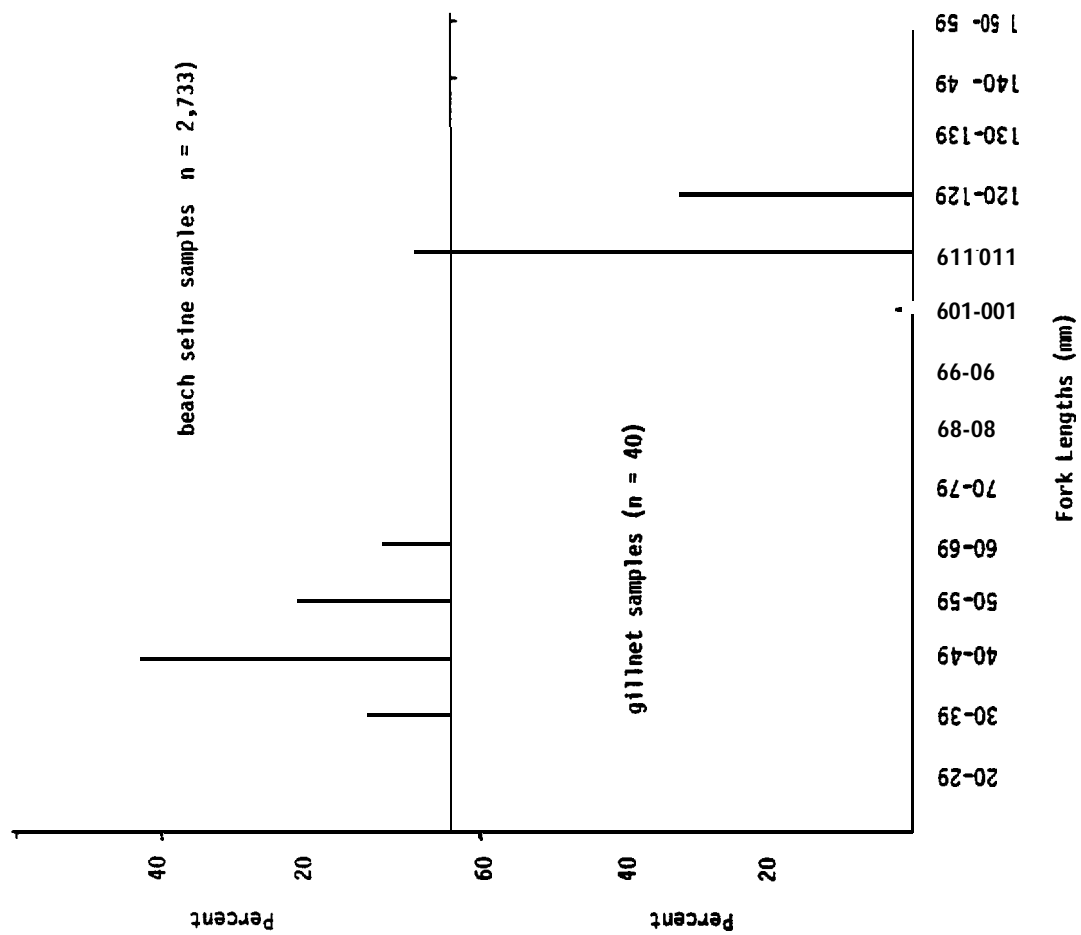


Figure 33. Length frequency (percent) of pond smelt by gear type captured in nearshore waters of Norton Sound from June through October, 1977.

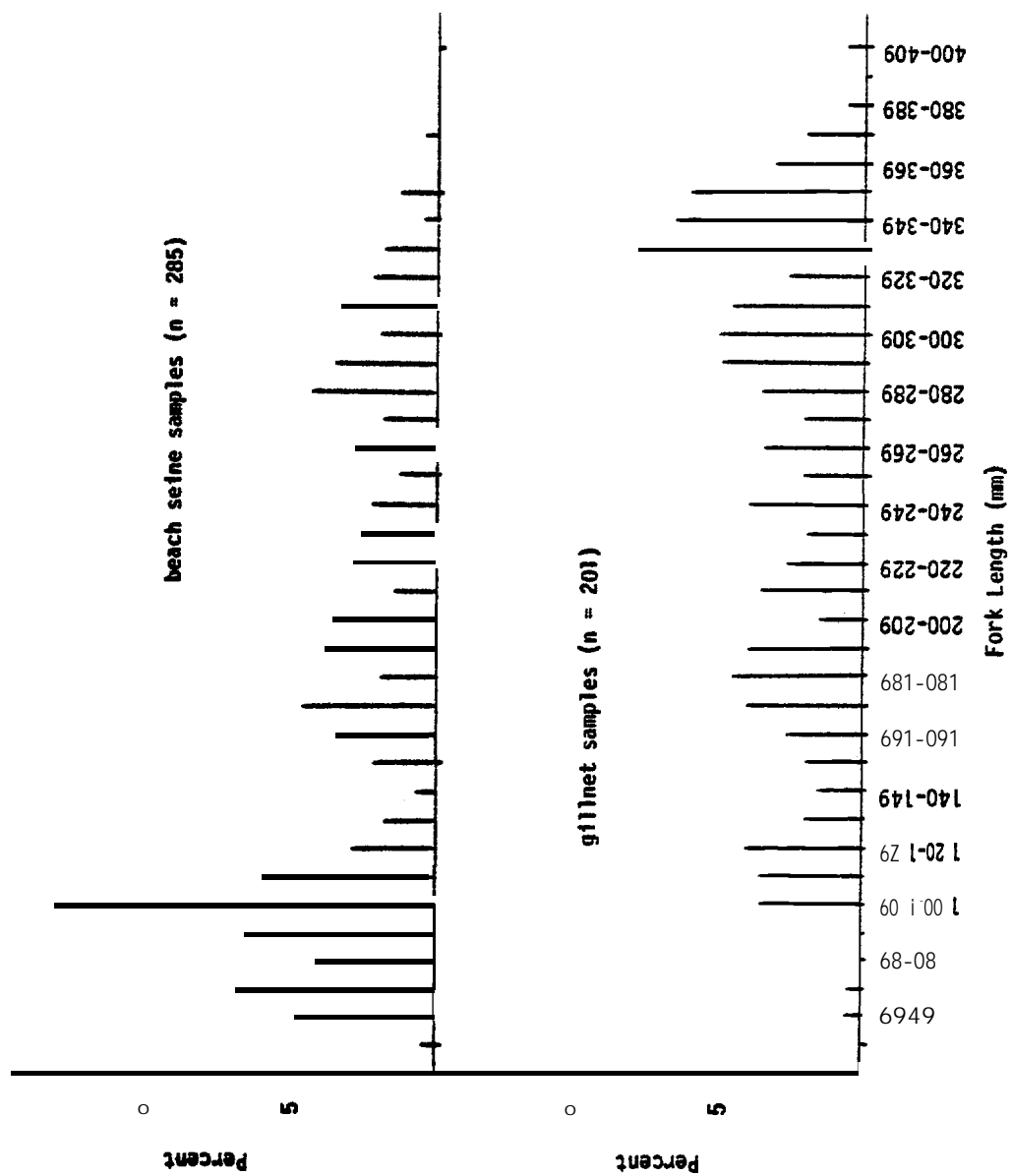


Figure 34. Length frequency (percent) of Bering cisco by gear type captured in nearshore waters of Norton Sound from June through October, 1977.

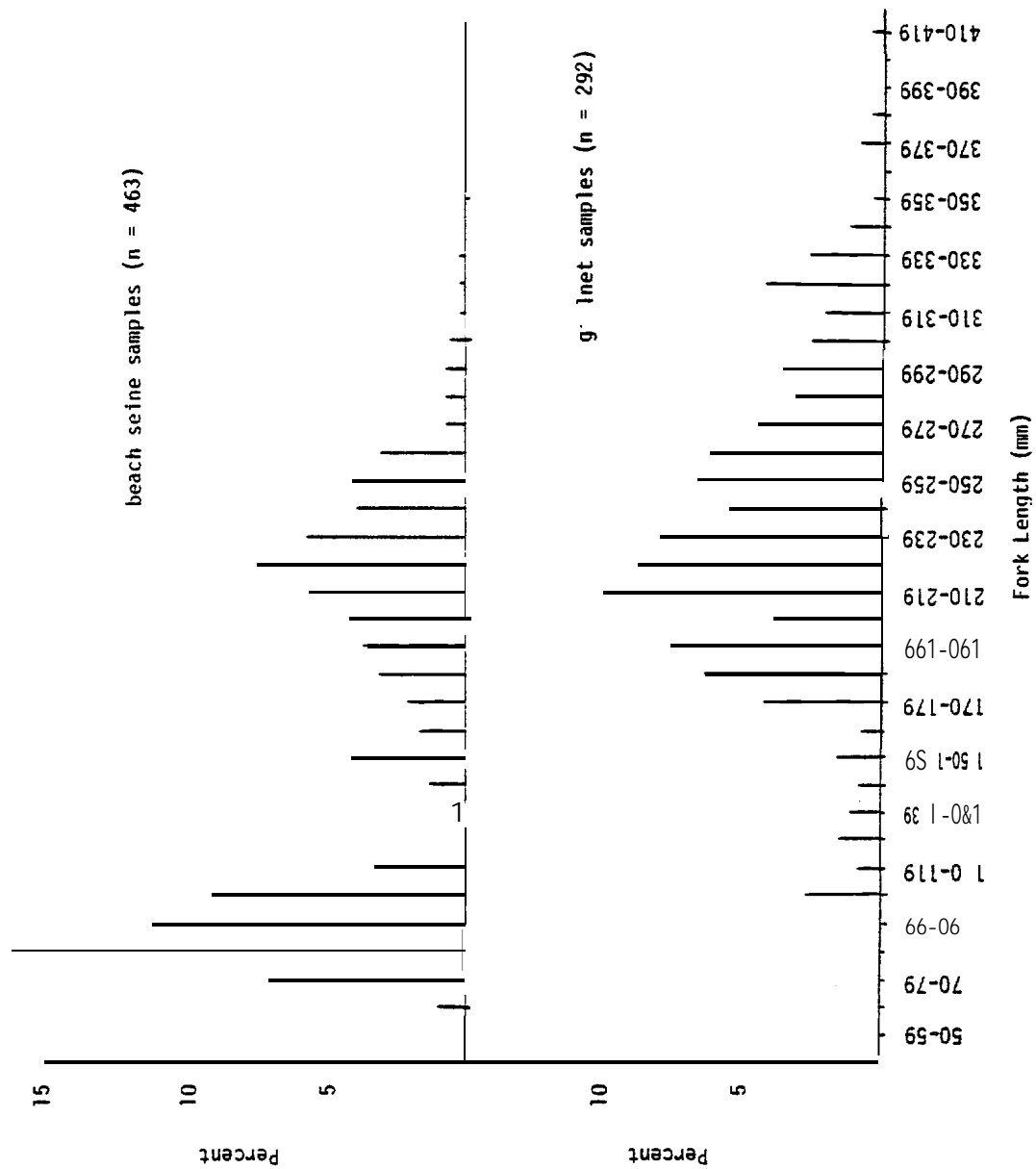


Figure 35. Length frequency (percent) of least cisco by gear type captured in nearshore waters of Norton Sound from June through October, 1977.

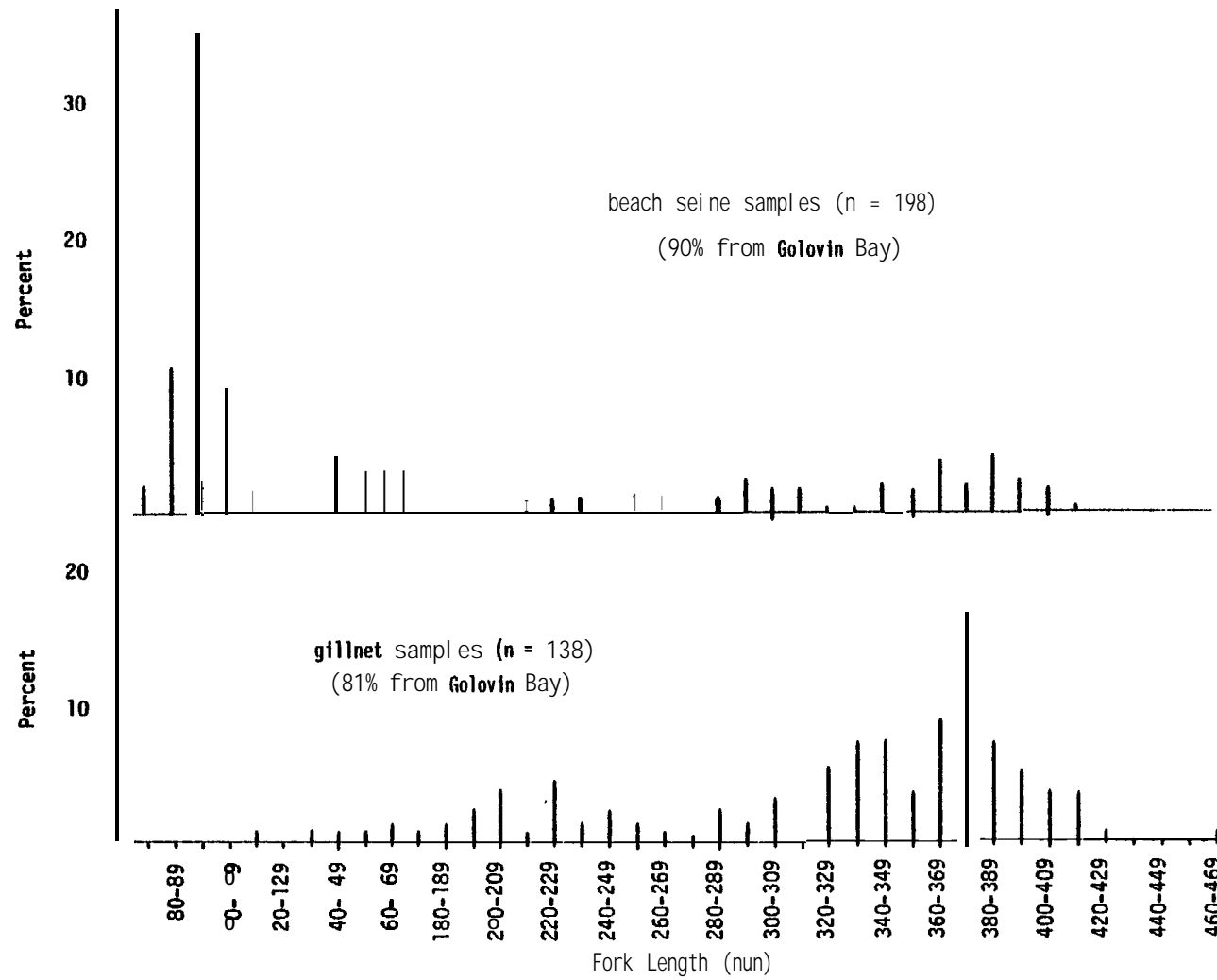


Figure 36. Length frequency (percent) of humpback whitefish by gear type captured in nearshore waters of Norton Sound from June through October, 1977.

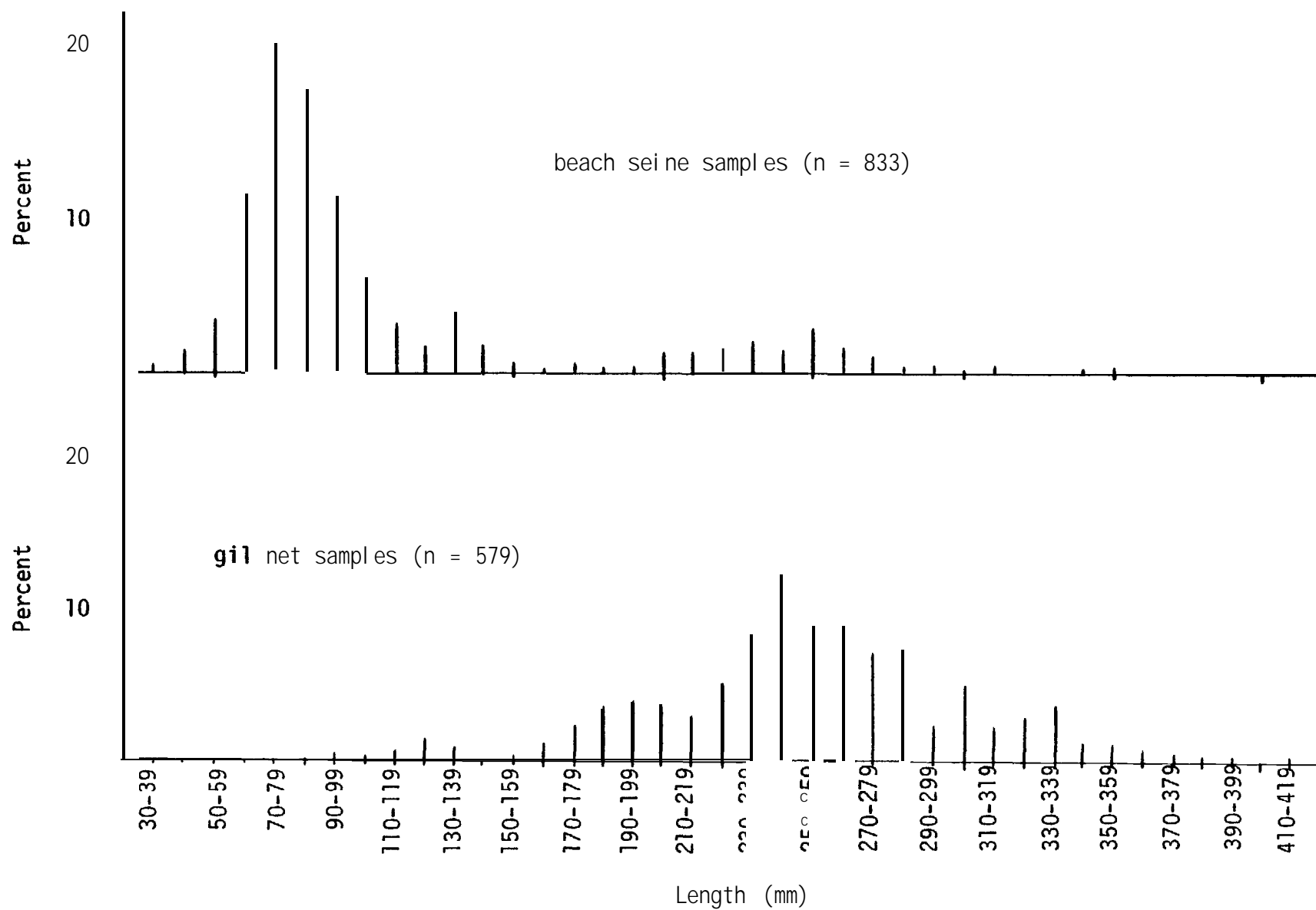


Figure 37. Length frequency (percent) of saffron cod captured in beach seines and gillnets in the near-shore waters of Norton Sound, 1977.

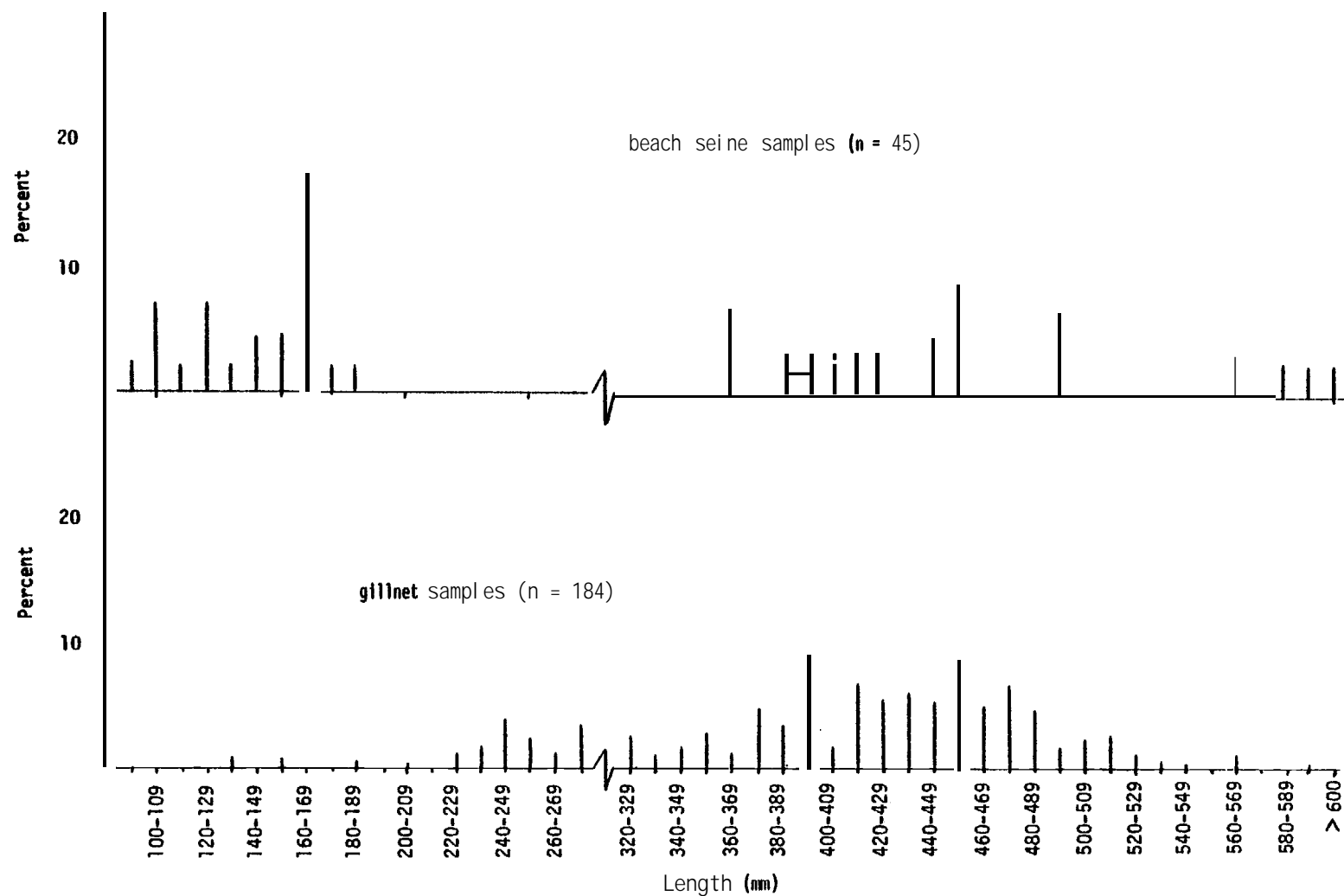


Figure 38. Length frequency (percent) of Arctic char by gear type captured in nearshore waters of Norton Sound from June through October, 1977.

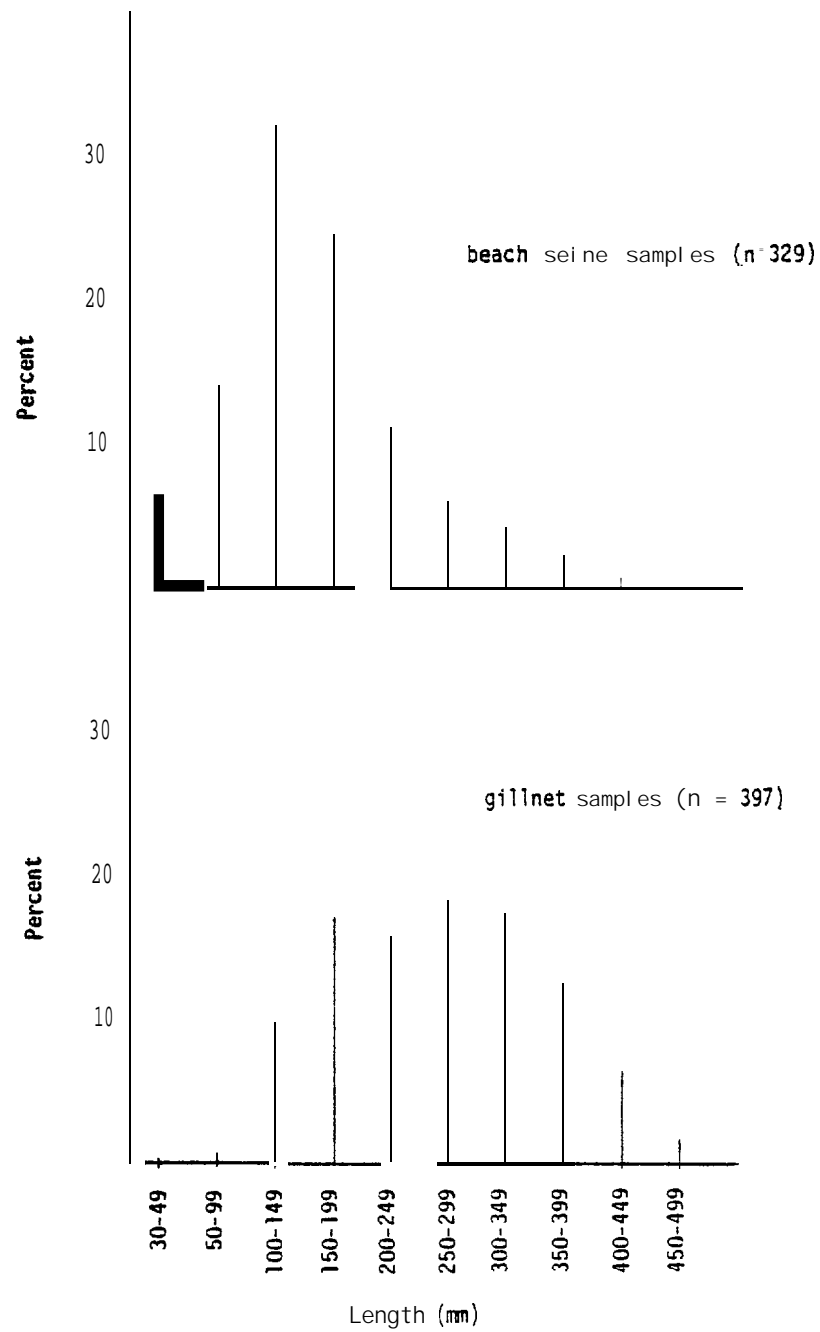


Figure 39. Length frequency (percent) of starry flounder by gear type captured in near-shore waters of Norton Sound from June through October, 1977.

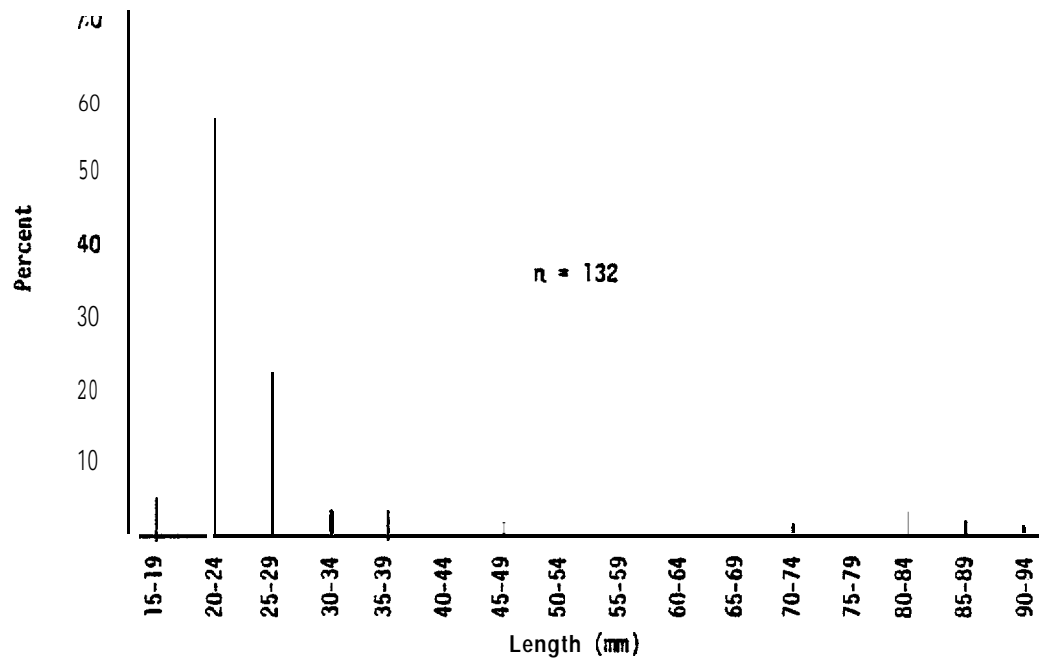


Figure 40. Length frequency (percent) of threespine sticklebacks captured in the nearshore waters of Norton Sound, 1977.

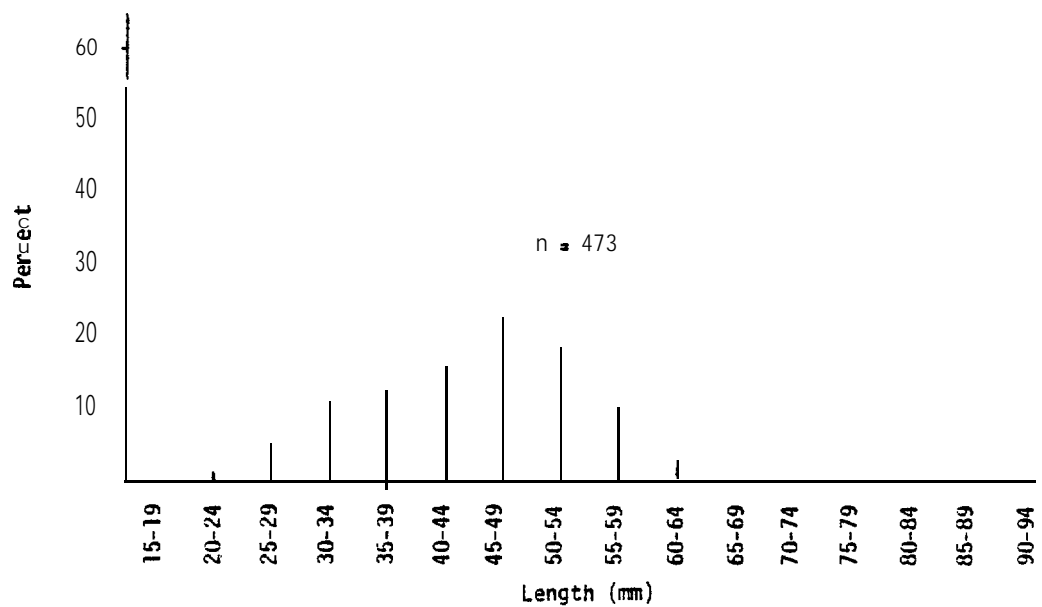


Figure 41. Length frequency (percent) of ninespine stickleback captured in the nearshore waters of Norton Sound, 1977.

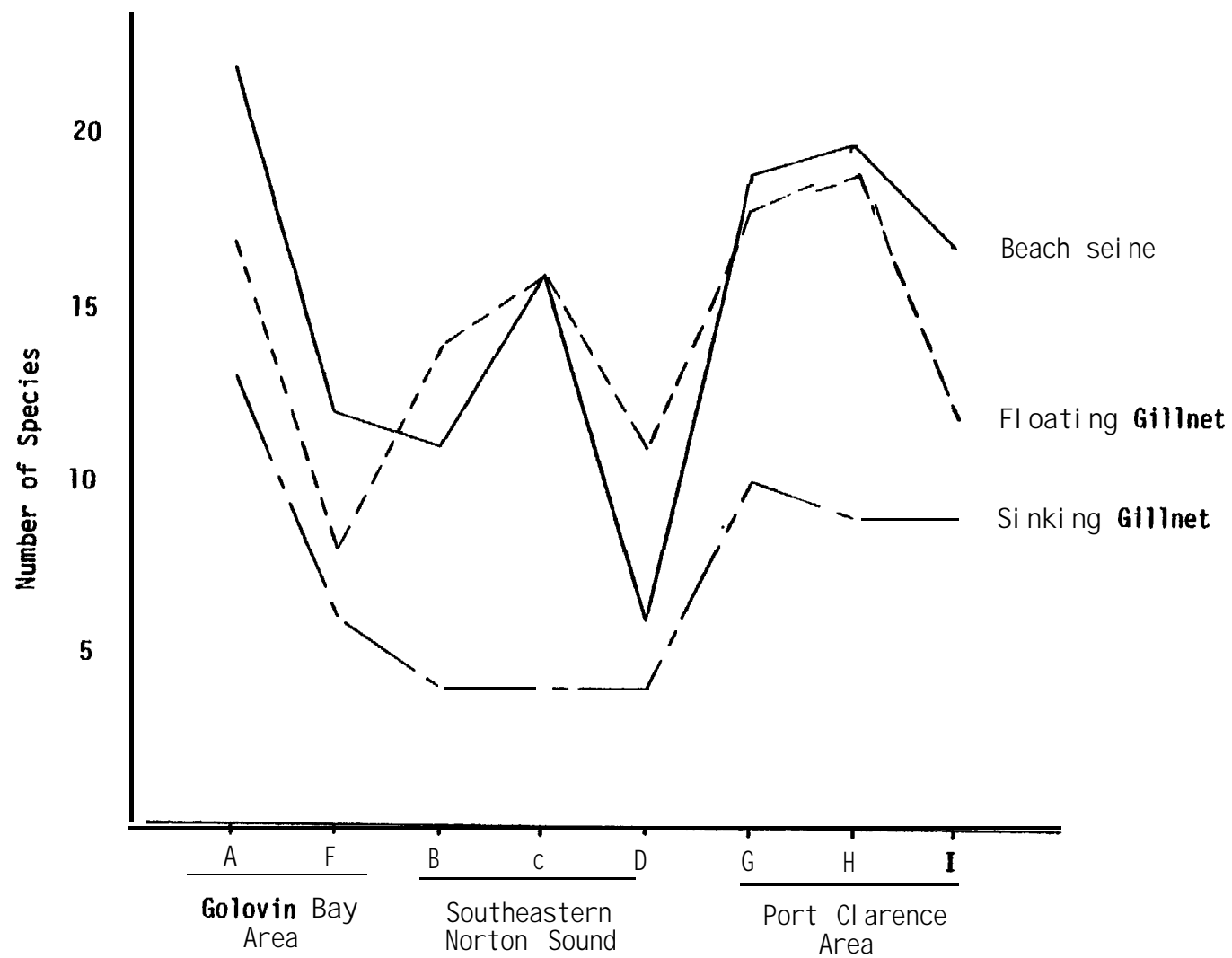


Figure 42. Species diversity by gear type of fish captured in the nearshore waters of Norton Sound from June through October, 1976-77.

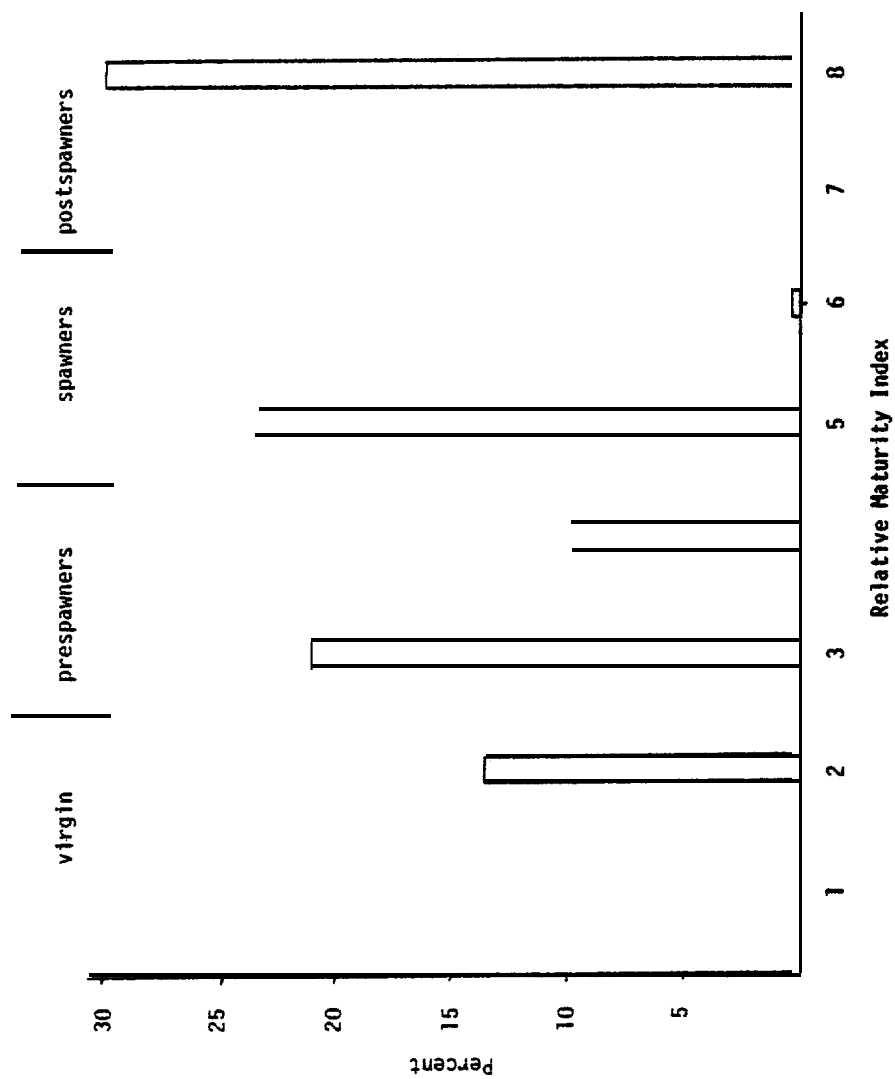


Figure 43. Relative maturity of herring captured in the offshore surface waters of Norton Sound from June 22 through July 12, 1977.

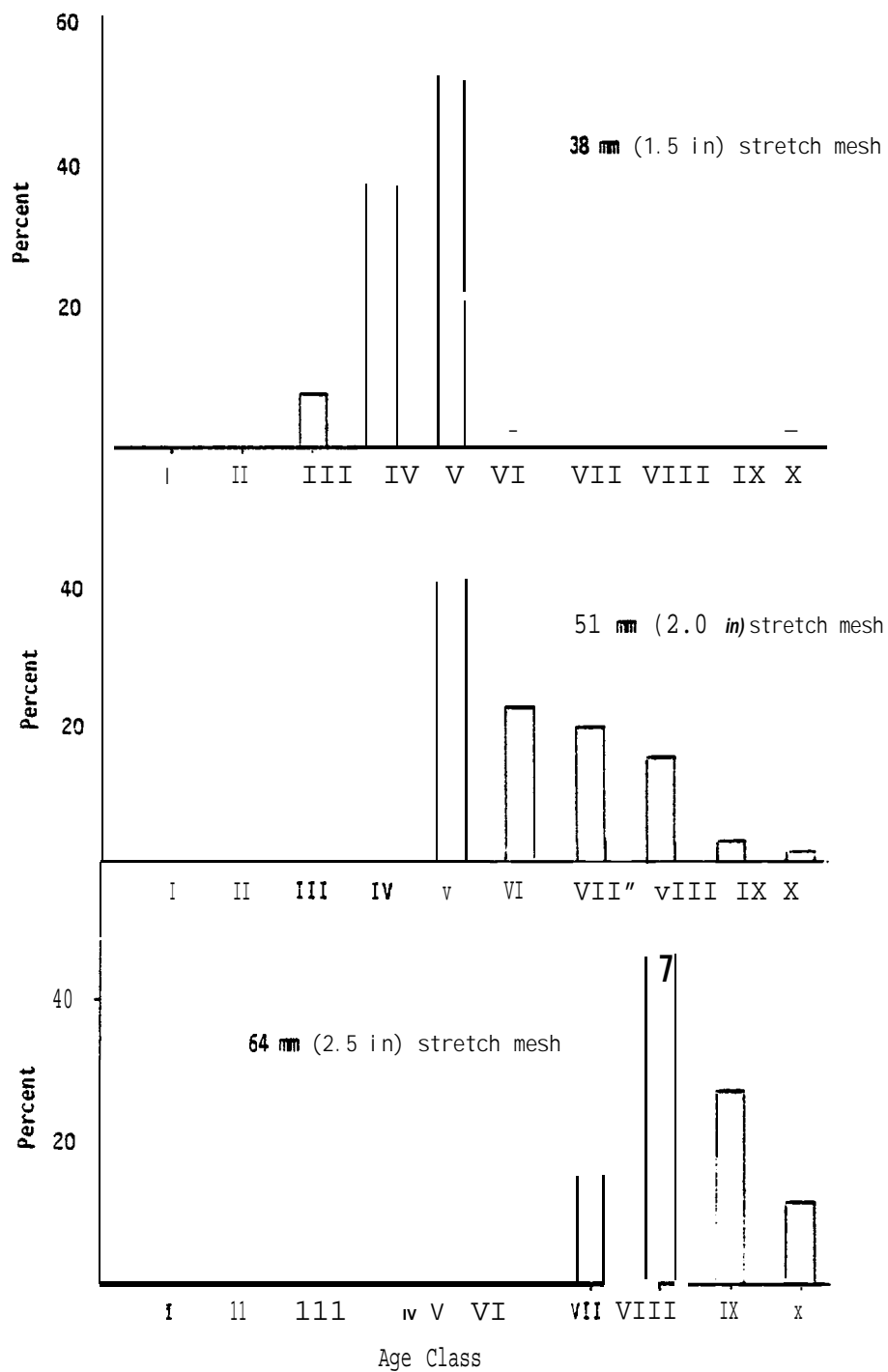


Figure 44. Mesh selectivity of **gillnets** to age classes of herring captured in the offshore waters of Norton Sound from June 22 through July 12, 1977.

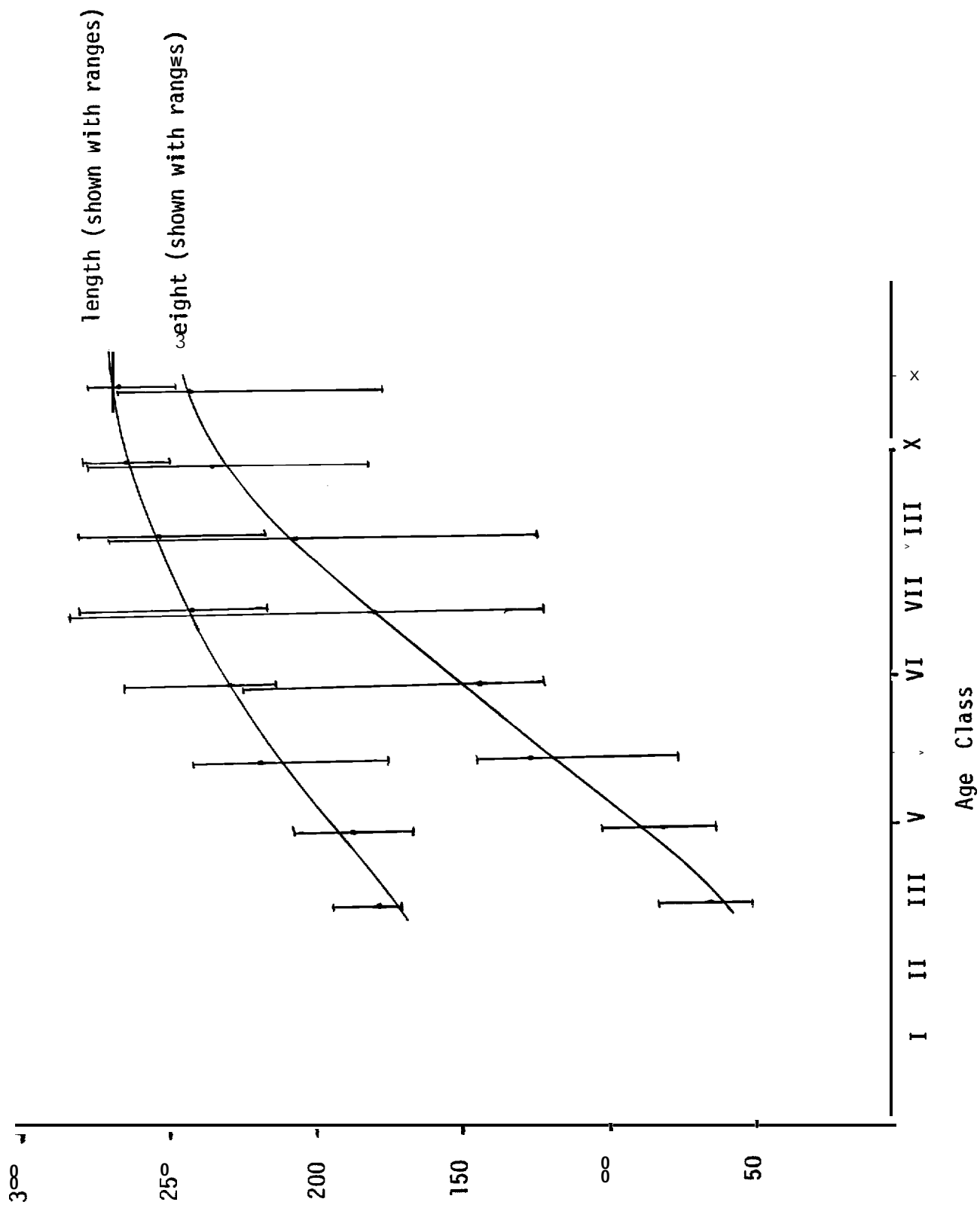


Figure 45. Mean length and weight-at-age for herring collected in the offshore surface waters of Norton Sound from June 22 through July 9, 1977.

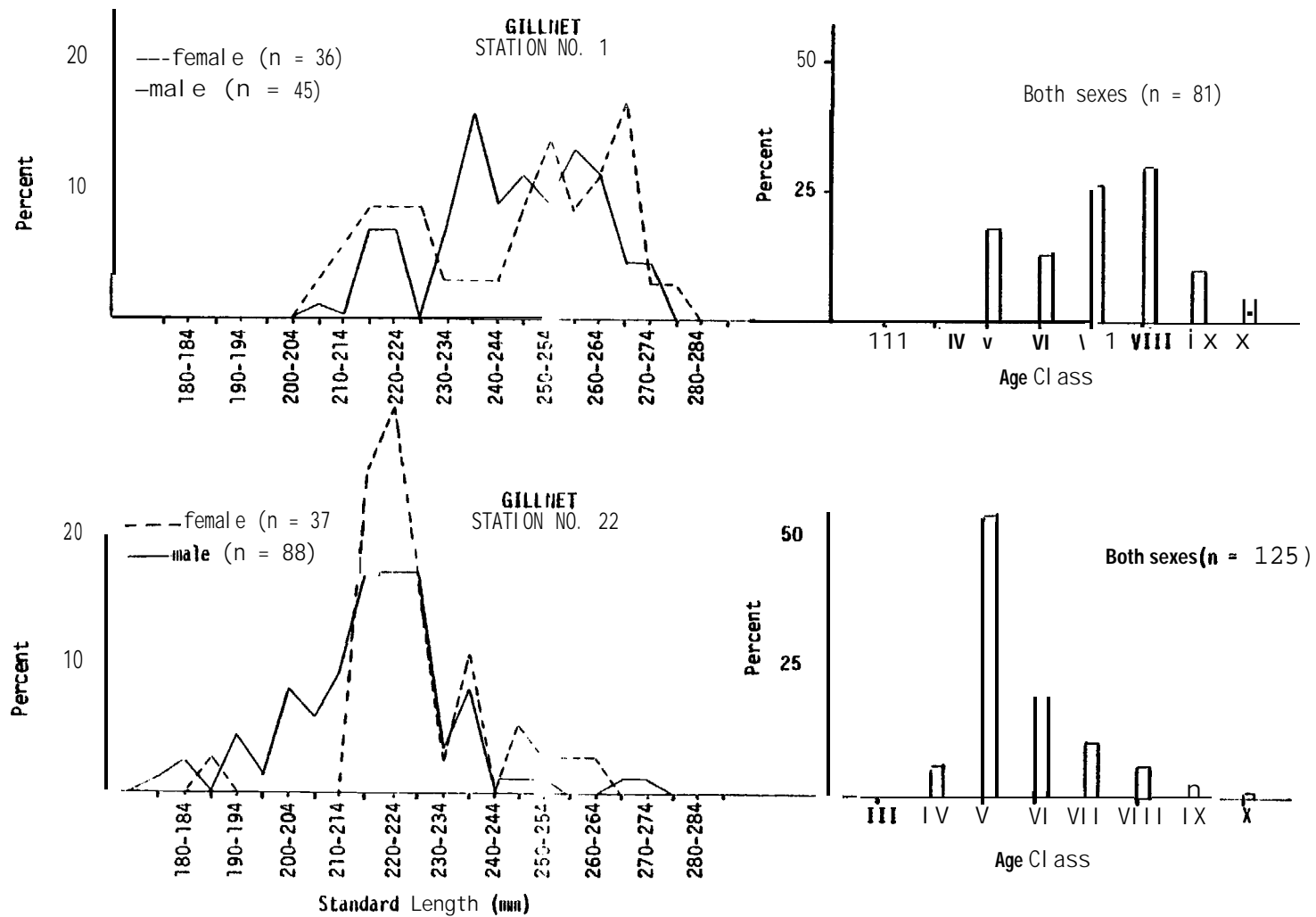


Figure 46. Length frequency and percent age composition of herring captured at stations 1 and 20 in Norton Sound during the M/V Royal Atlantic cruise from June 22 through July 12, 1977.

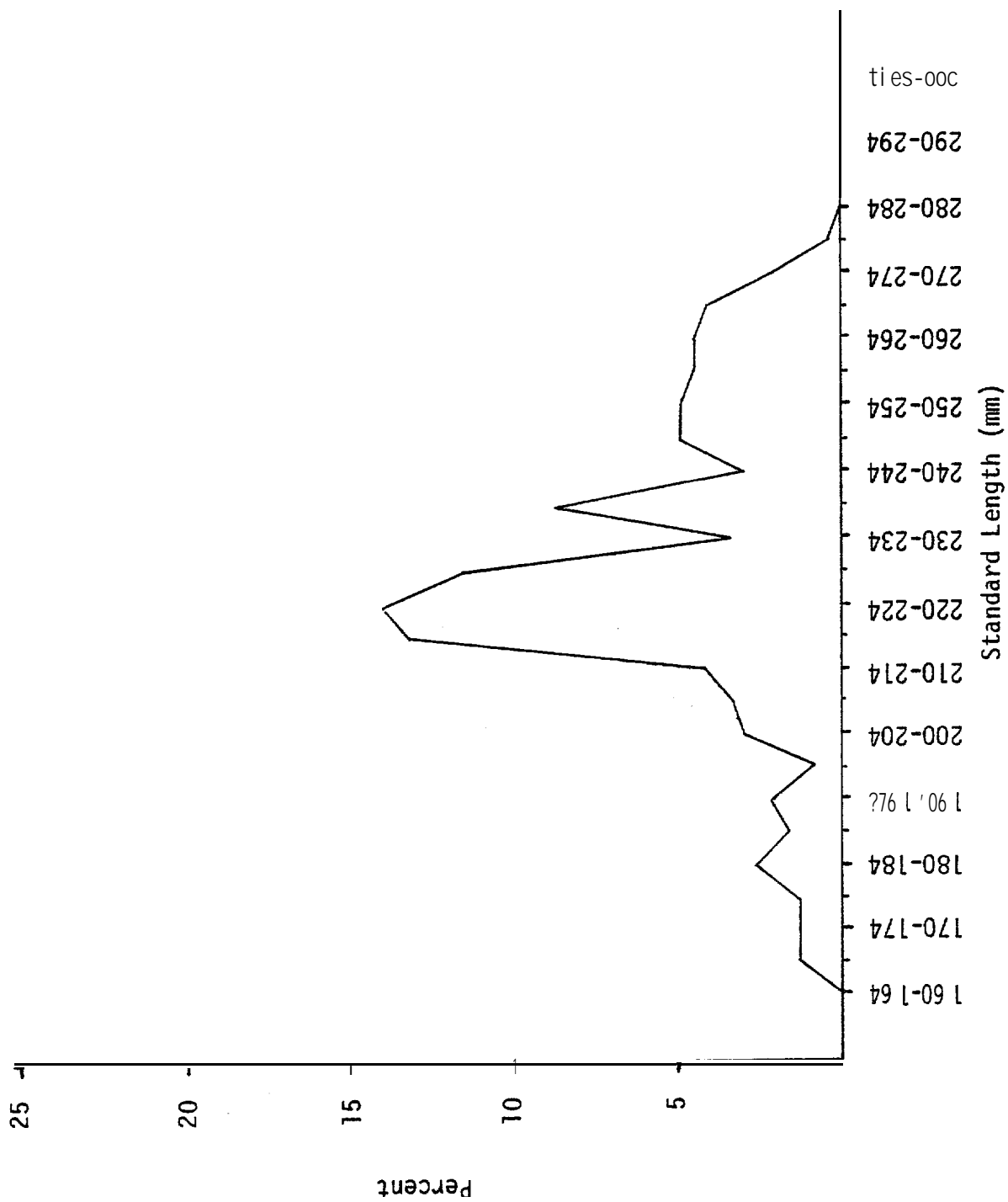
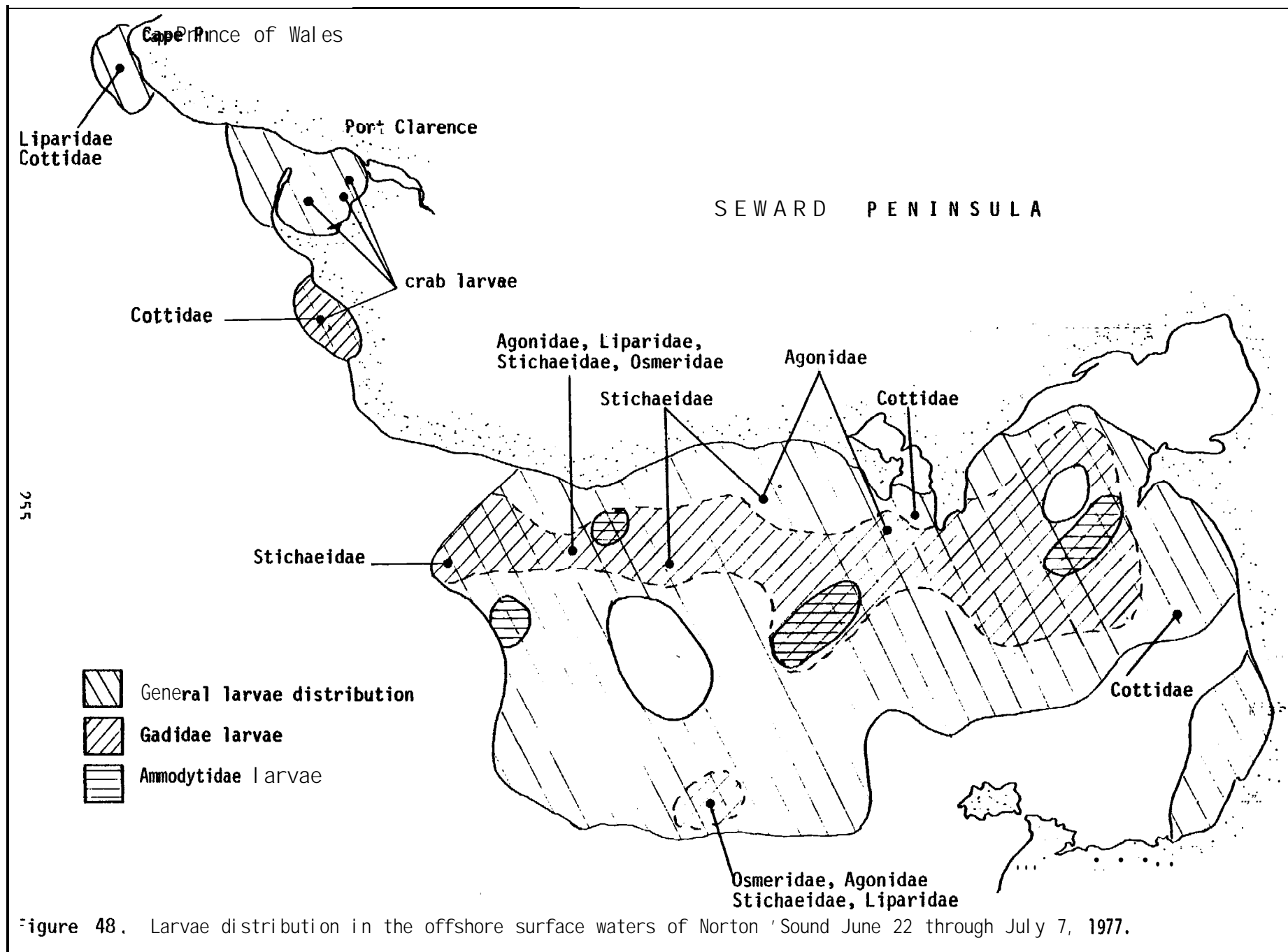


Figure 47. Length frequency (percent) of herring sampled in offshore surface waters of Norton Sound from June 22 through July 12, 1977.



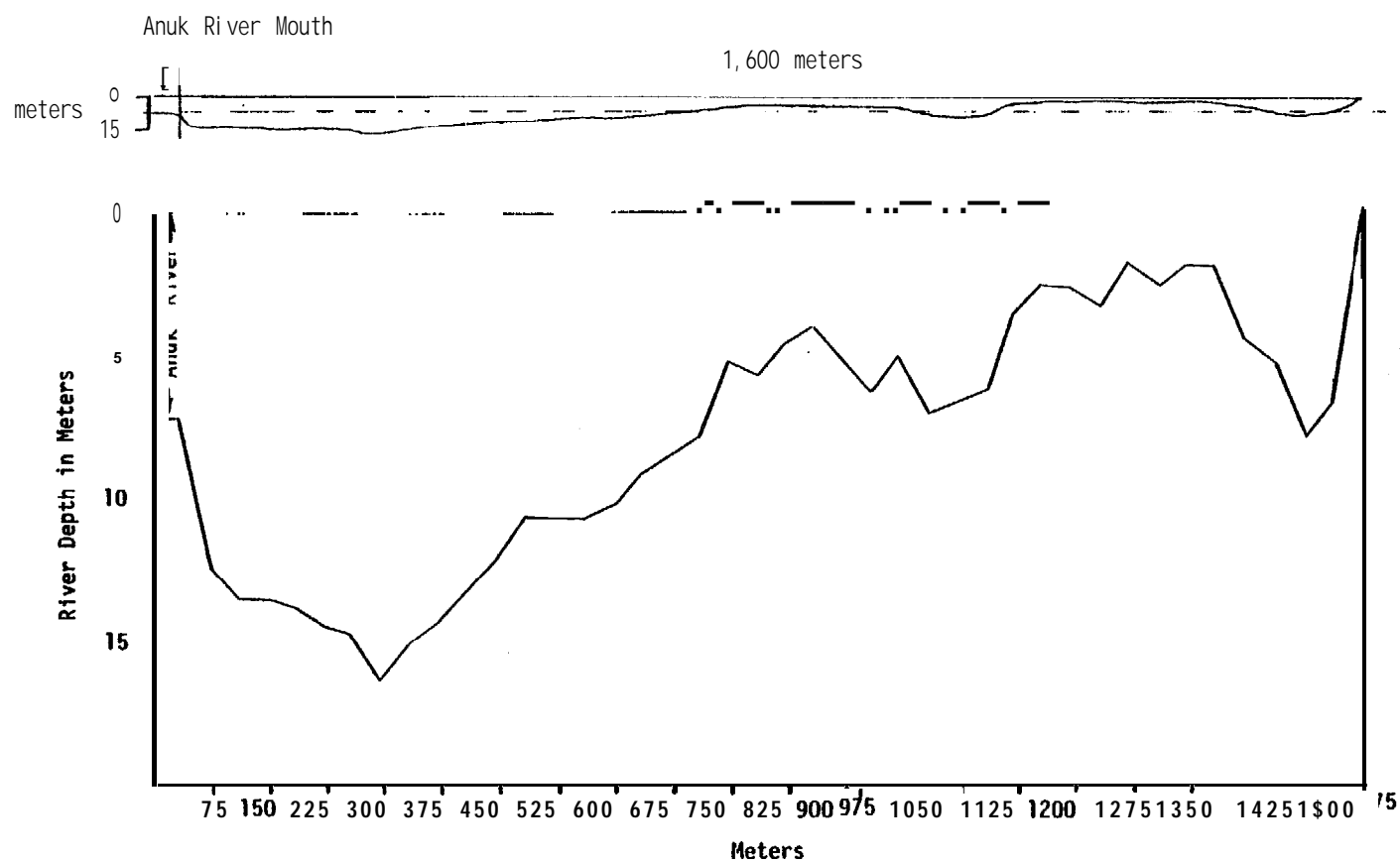


Figure 49. Exaggerated profile of the Yukon River 101 kilometers upriver from Flat Island, 1977. This site was location for smelting studies.

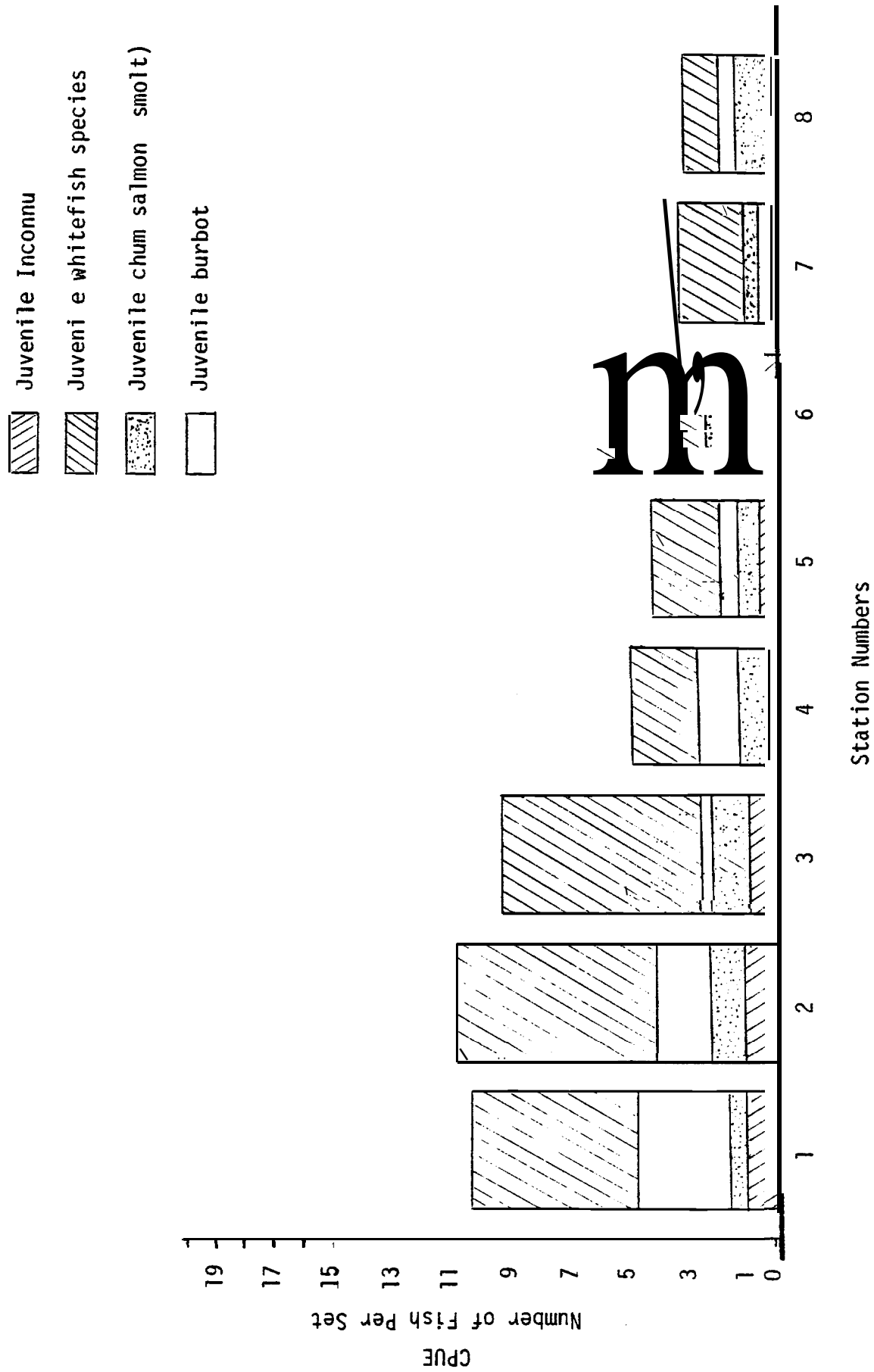


Figure 50. Catch per unit effort for four fish groups by station number captured in the Yukon River from June 7 through July 7, 1977. Site location was at the confluence of the Anuk River.

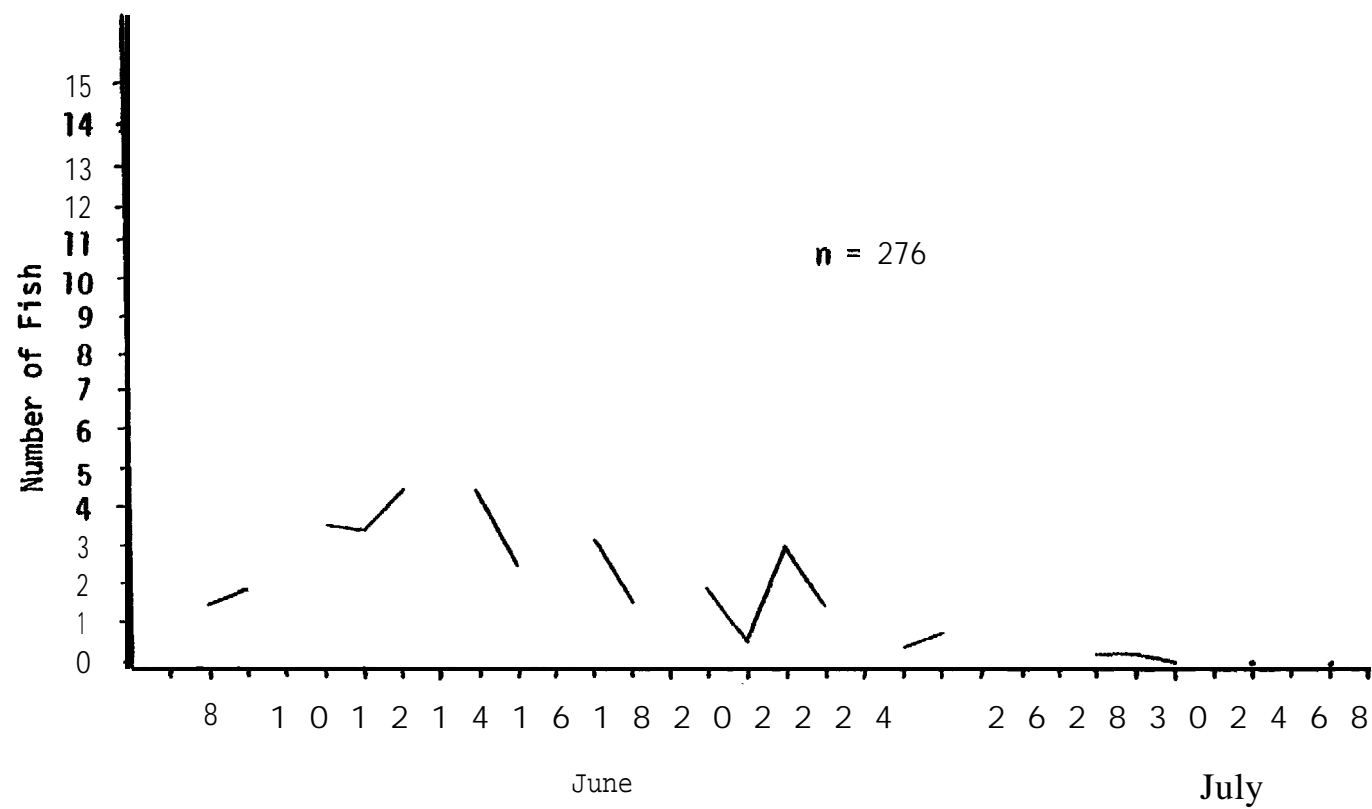


Figure 51. Timing and abundance of chum salmon smelt down the Yukon River 101 kilometers upriver from Flat Island in June, 1977.

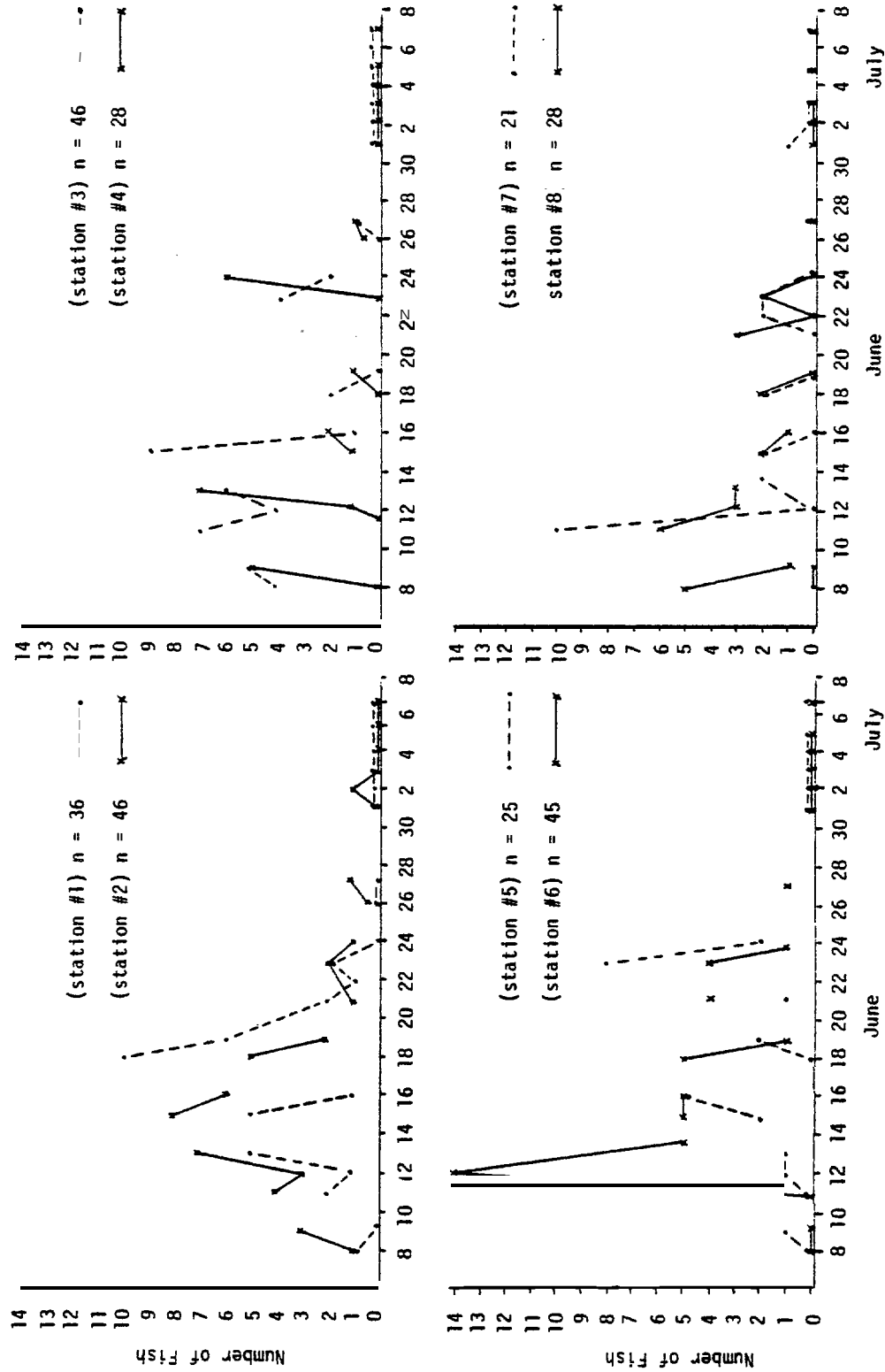


Figure 52 Spatial and temporal distribution of chum salmon smolt in the Yukon River 10 kilometers upriver from Flat Island in June, 1977.

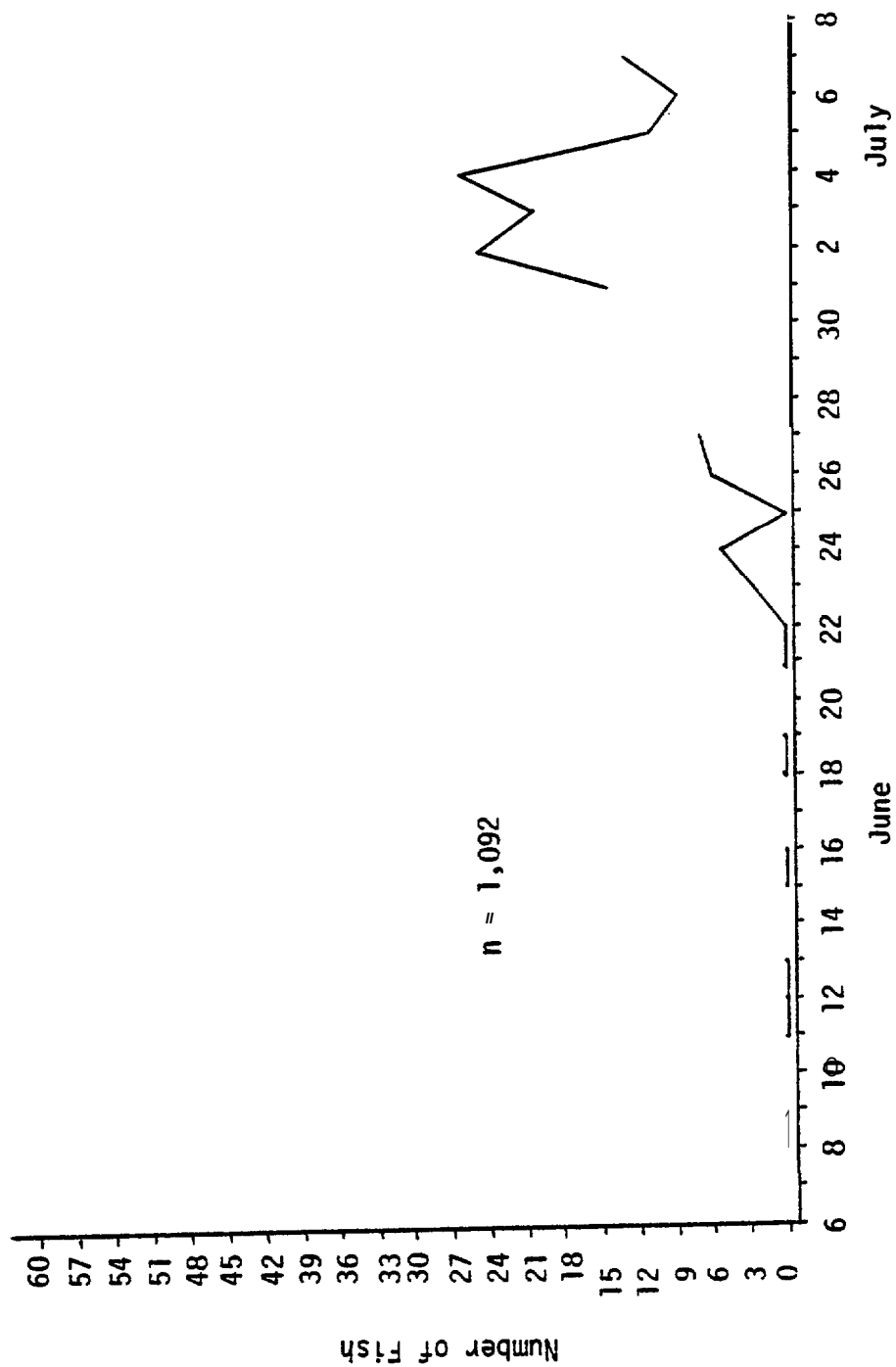


Figure 53. Timing and abundance of juvenile whitefish species down the Yukon River 101 kilometers upriver from Flat Island in June, 1977.

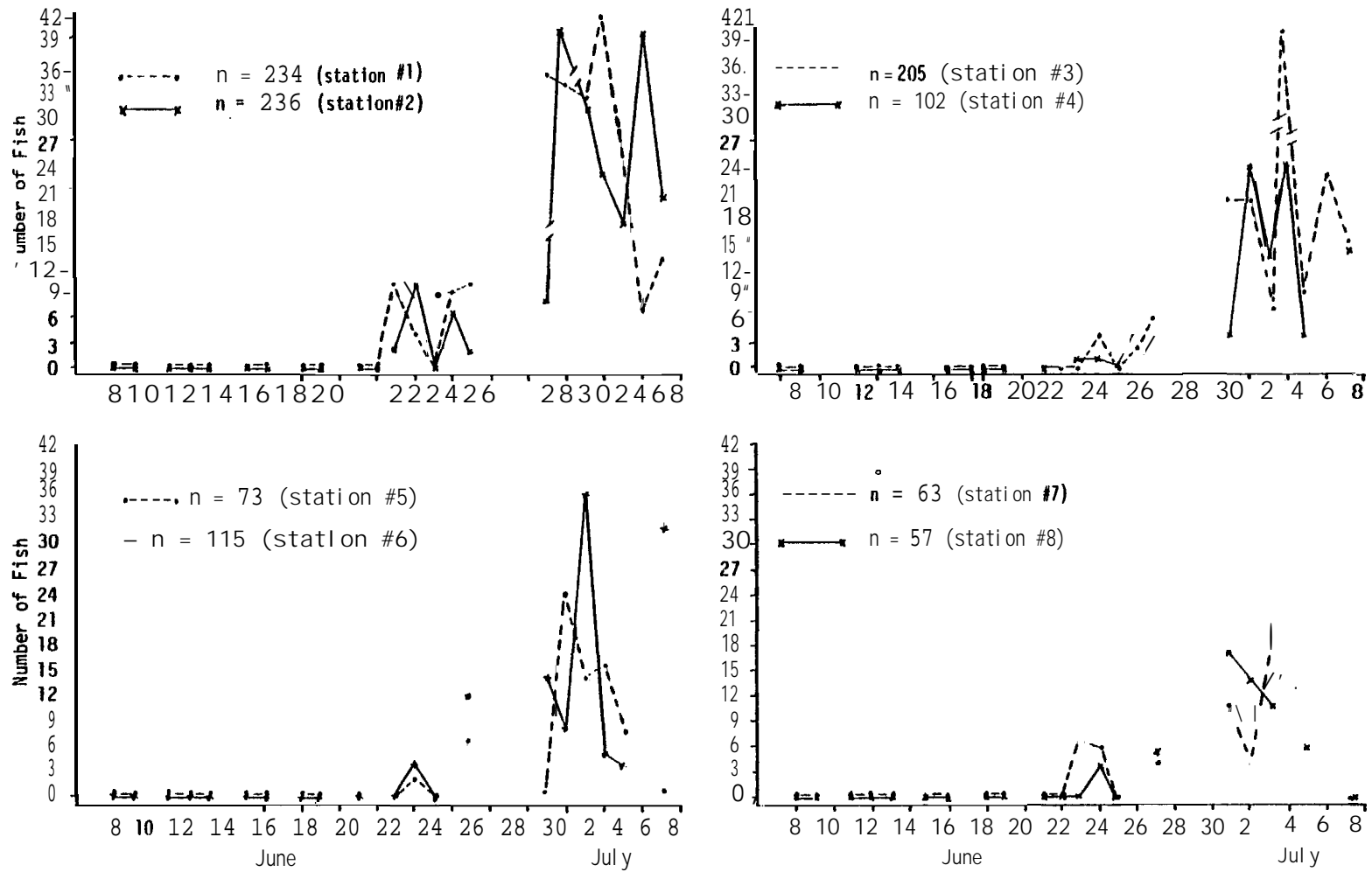


Figure 54. Spatial and temporal distribution of juvenile whitefish species down the Yukon River 101 kilometers upriver from Flat Island in June, 1977.

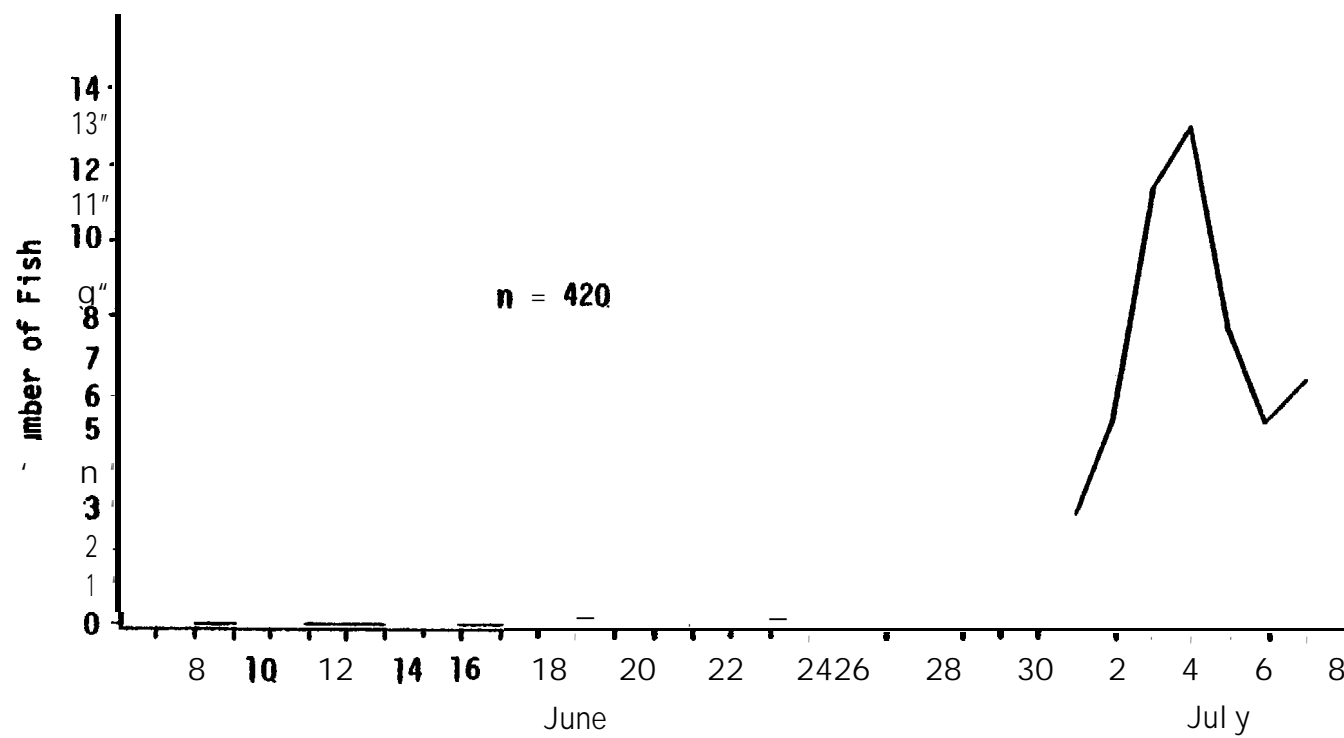


Figure 55. Timing and abundance of juvenile **burbot** down the "Yukon River 101 kilometers upriver from Flat Island in June, 1977.

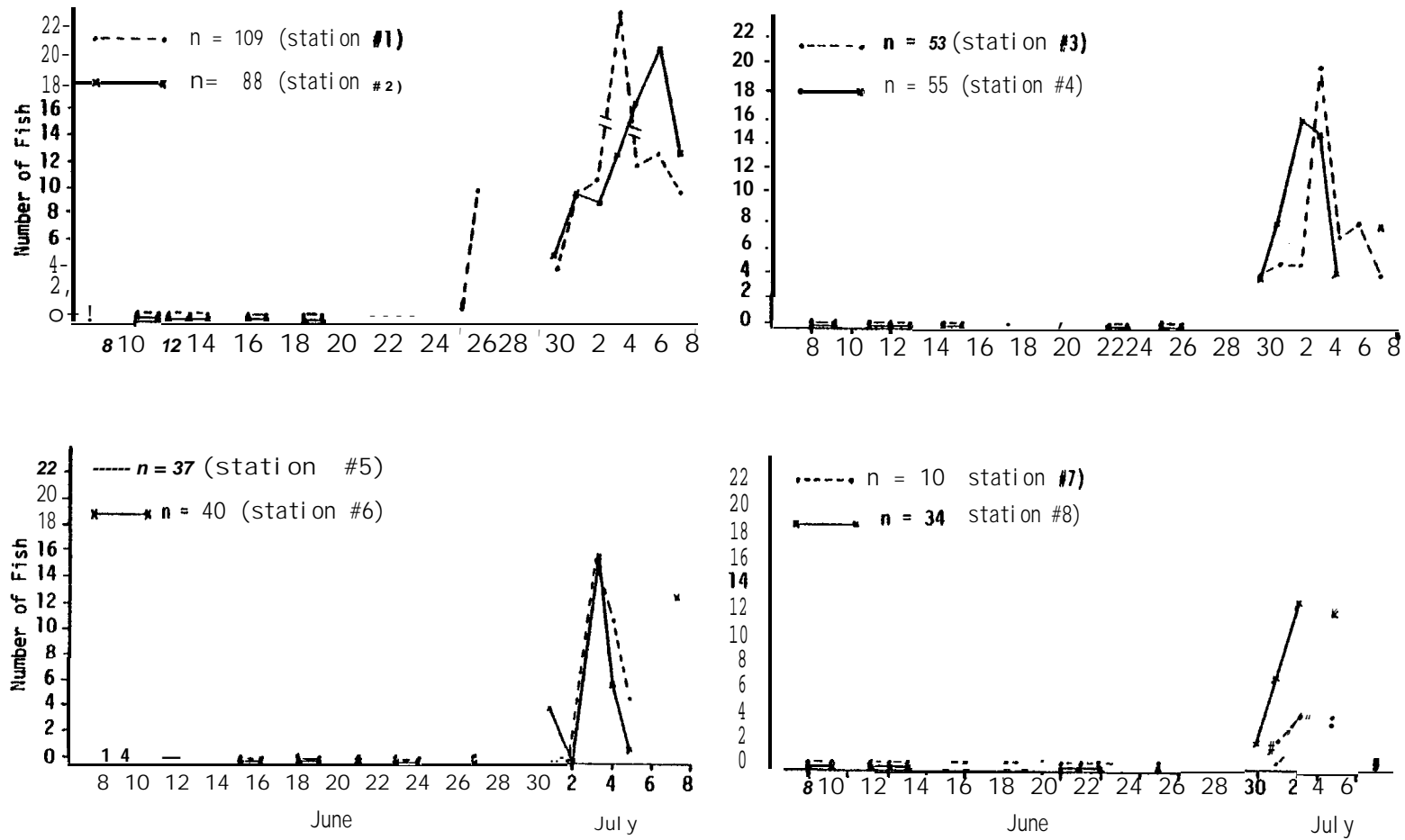


Figure 56. Spatial and temporal distribution of juvenile **burbot** down the Yukon River 101 kilometers upriver from Flat Island in June, 1977.

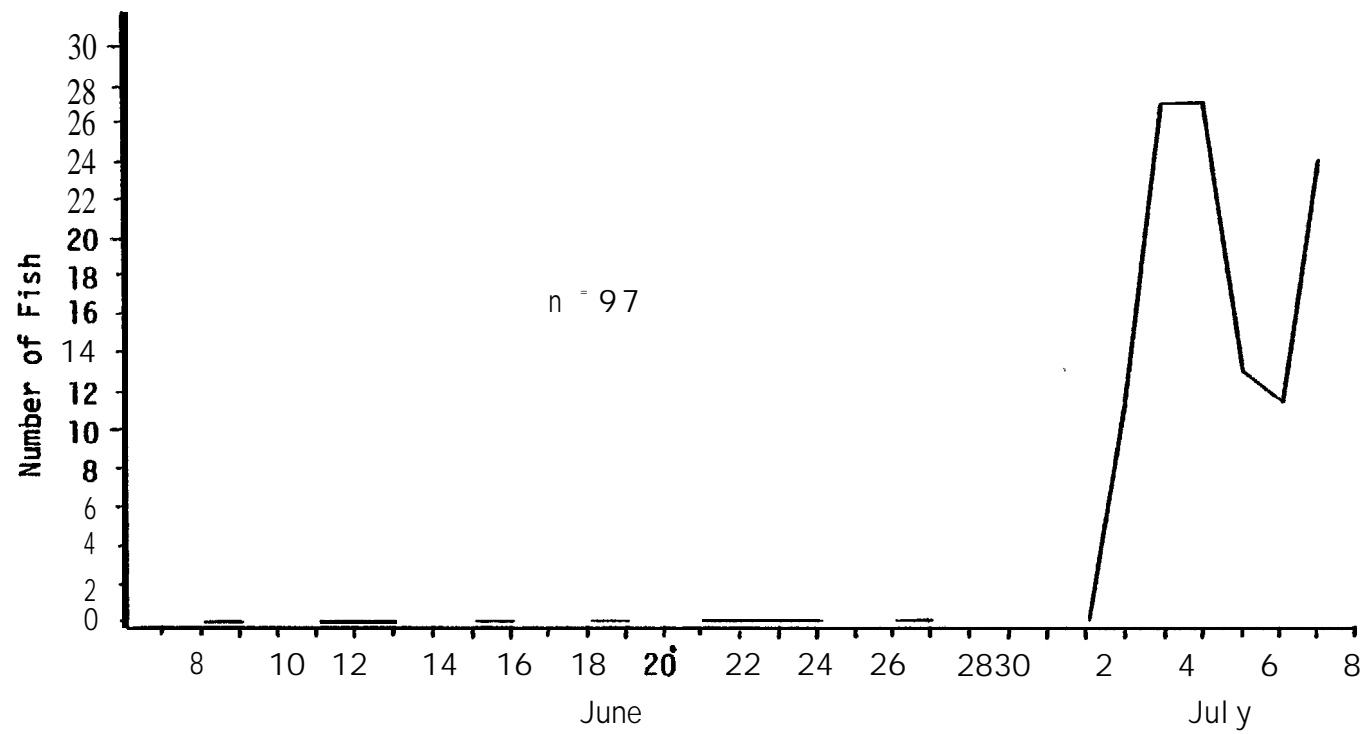


Figure 57 . Timing and abundance of juvenile **sheefish (Inconnu)** down the Yukon River 101 kilometers upriver from Flat Island in June, 1977.

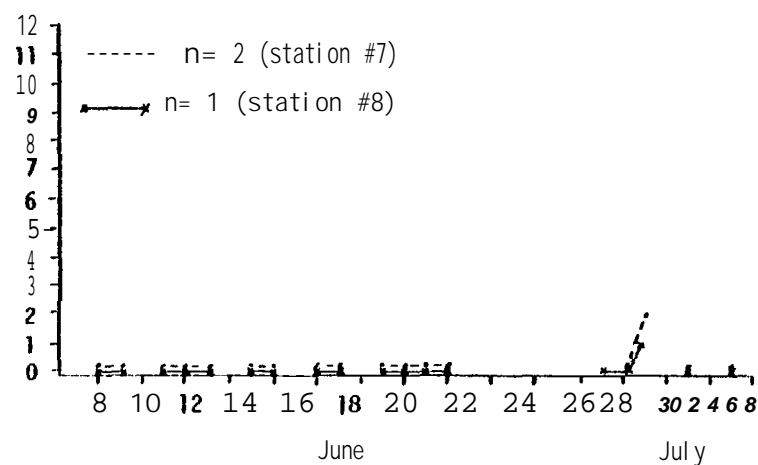
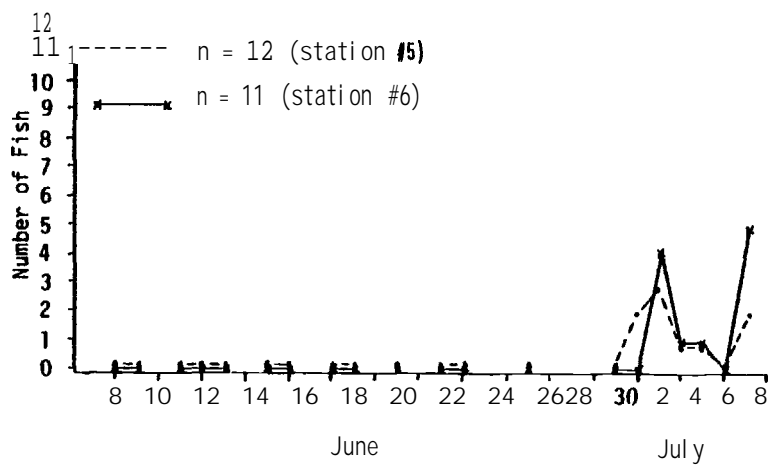
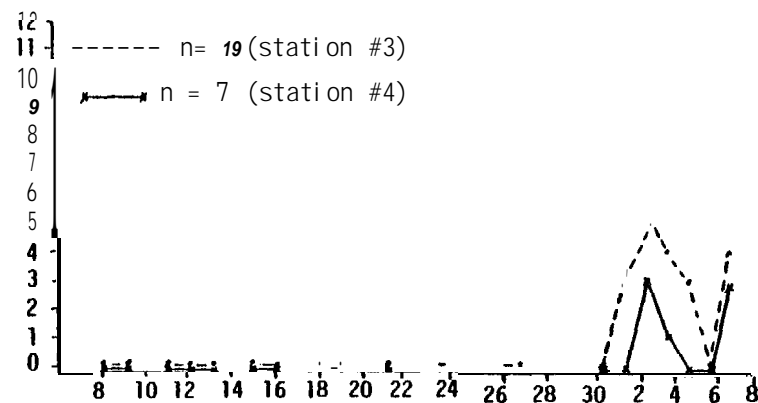
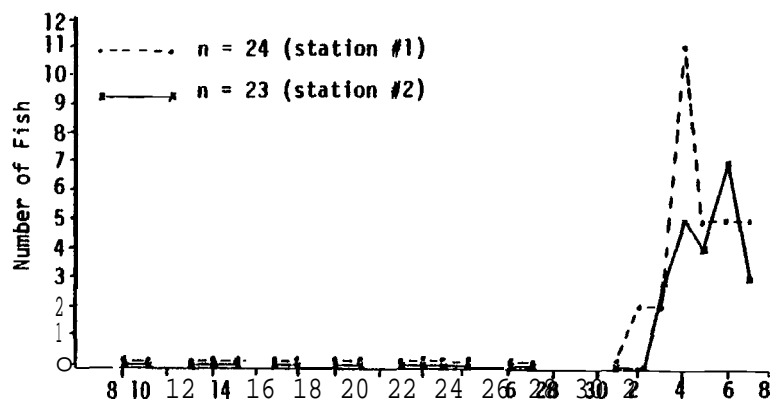


Figure 58. Spatial and temporal distribution of juvenile **sheefish (Inconnu)** down the Yukon River 101 kilometers upriver from **Flat** Island in June, 1977.

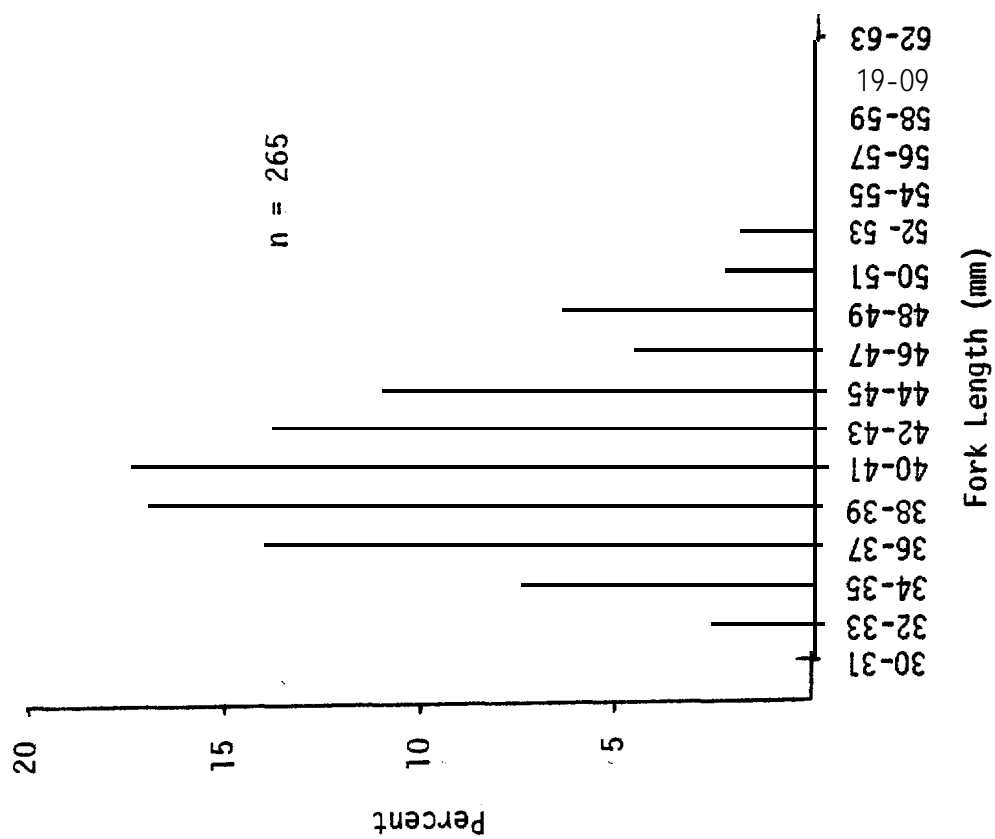


Figure 59. Length frequency (percent) of chum salmon smolt captured in the Yukon River 101 kilometers upstream from Flat Island, June 1977.

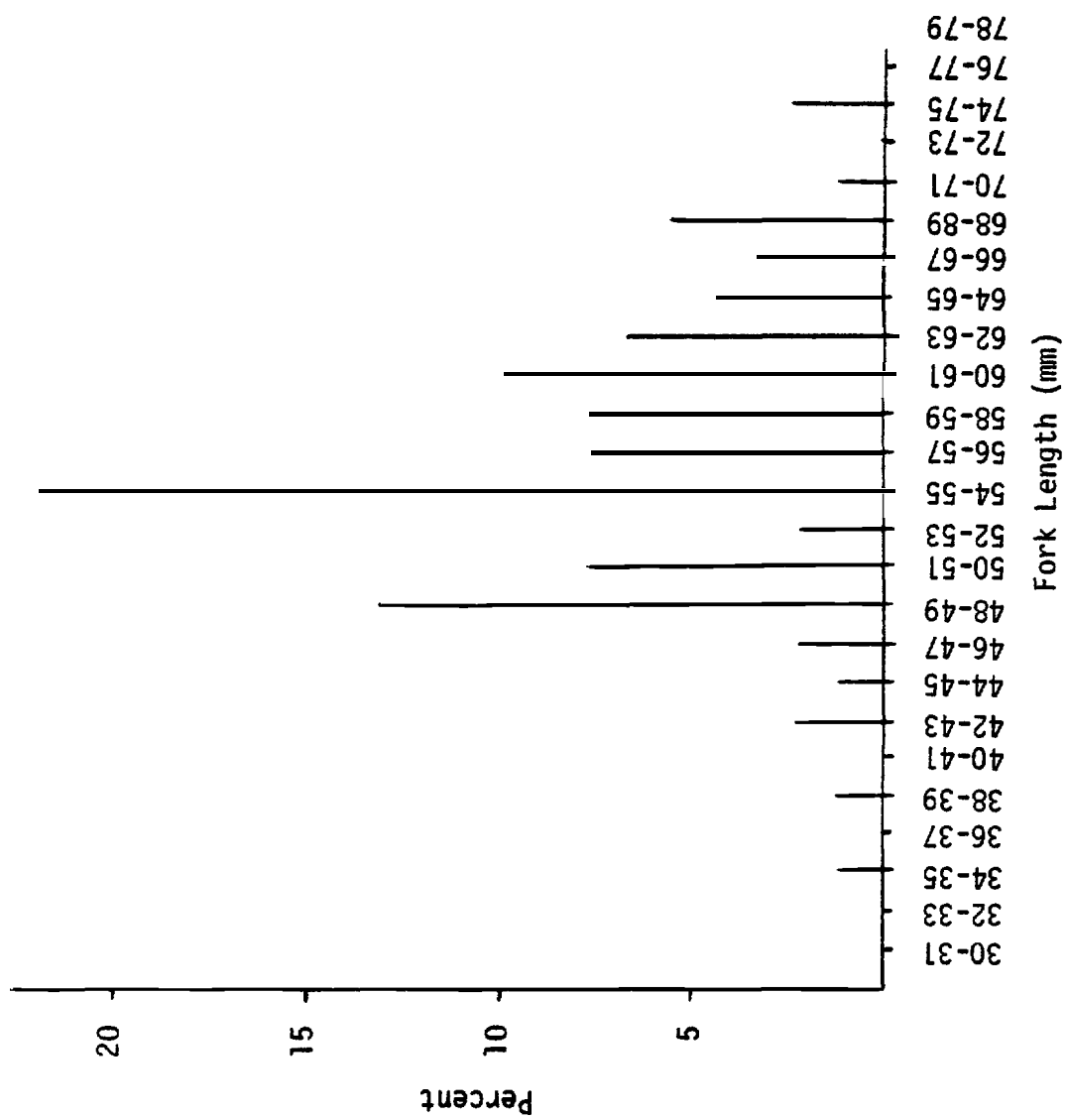


Figure 60. Length frequency (percent) of juvenile sheefish (Inconnu) captured in the Yukon River 101 kilometers upriver from Flat Island, June 1977.

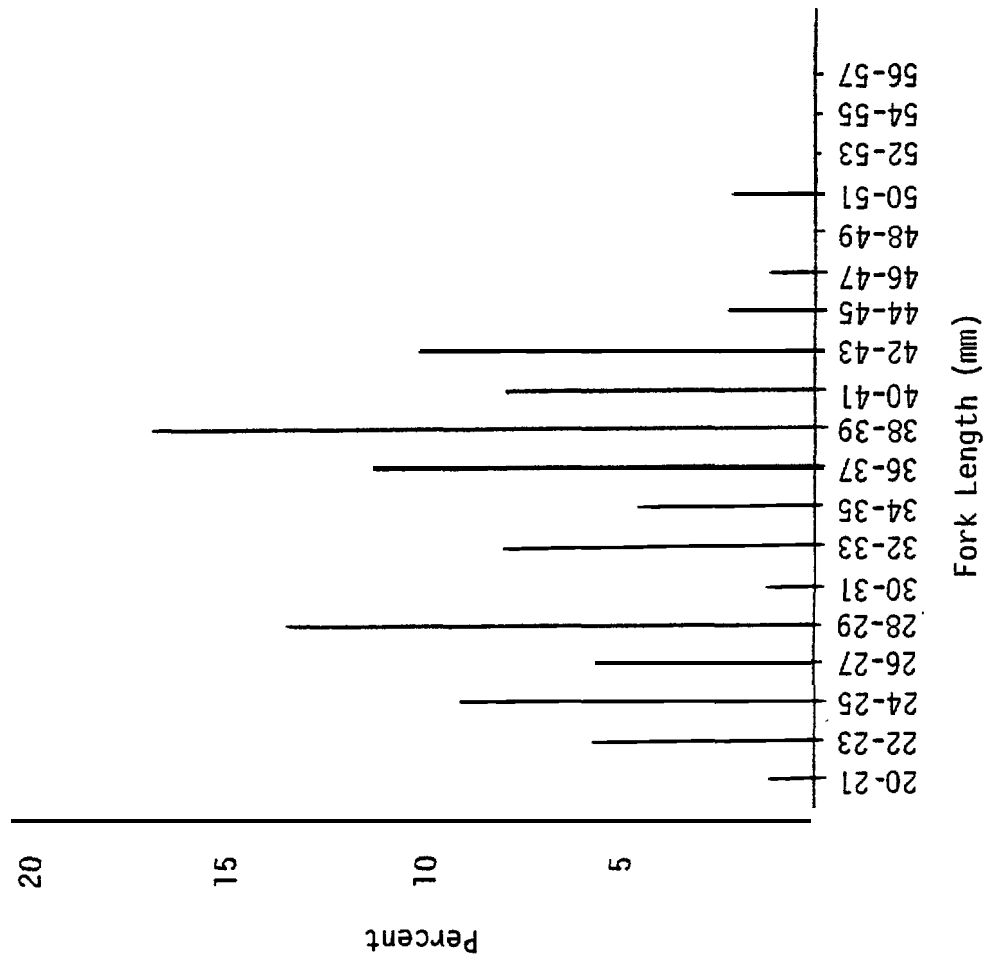


Figure 61 Length frequency (percent) of juvenile whitefish species captured in the Yukon River 101 kilometers upriver from Flat Island, June 1977.

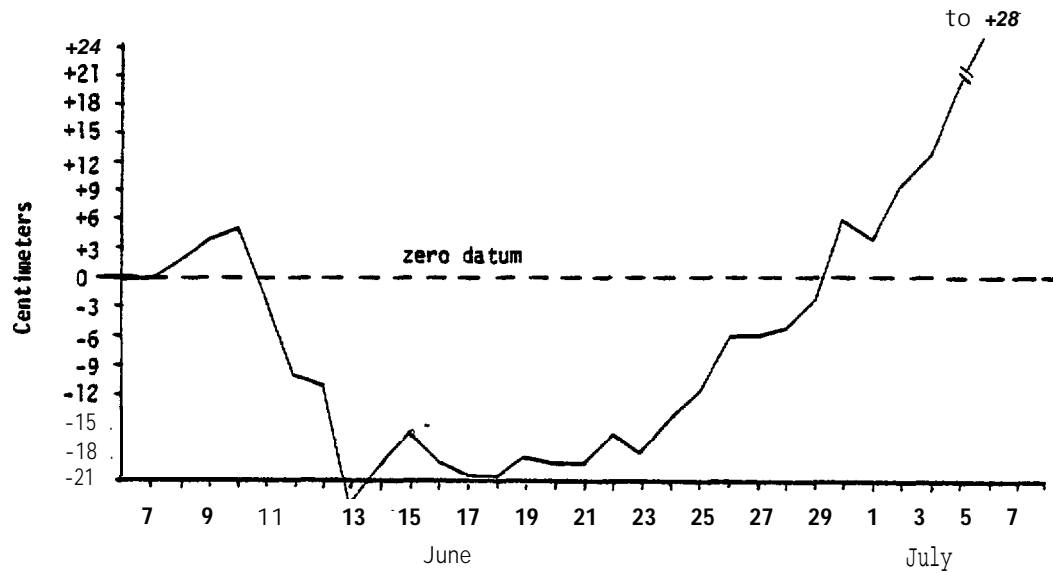


Figure 62. Water level fluctuations in the Anuk River one mile upriver from its confluence with the Yukon River, June 1977.

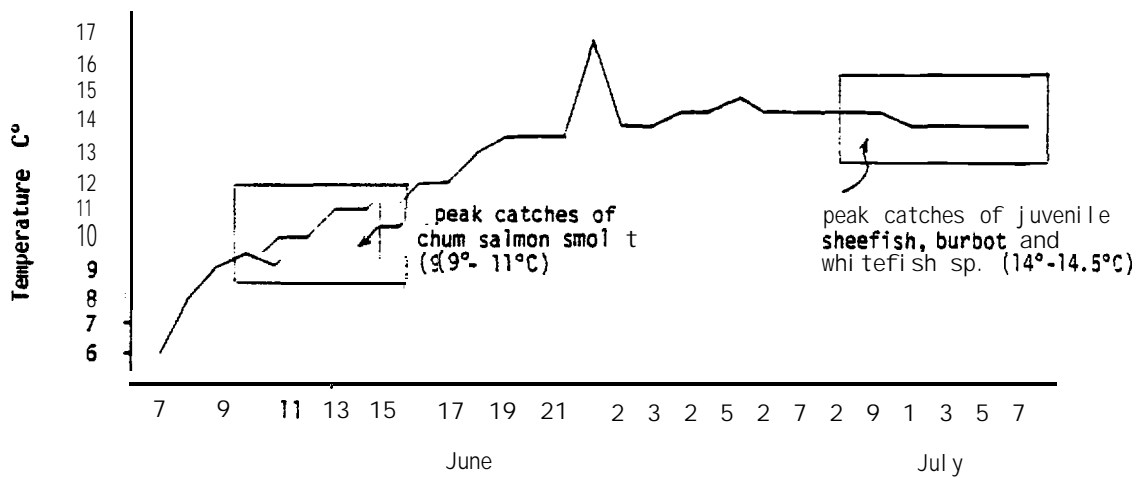


Figure 63. Yukon River surface water temperatures 101 kilometers upriver from Flat Island, June 1977.

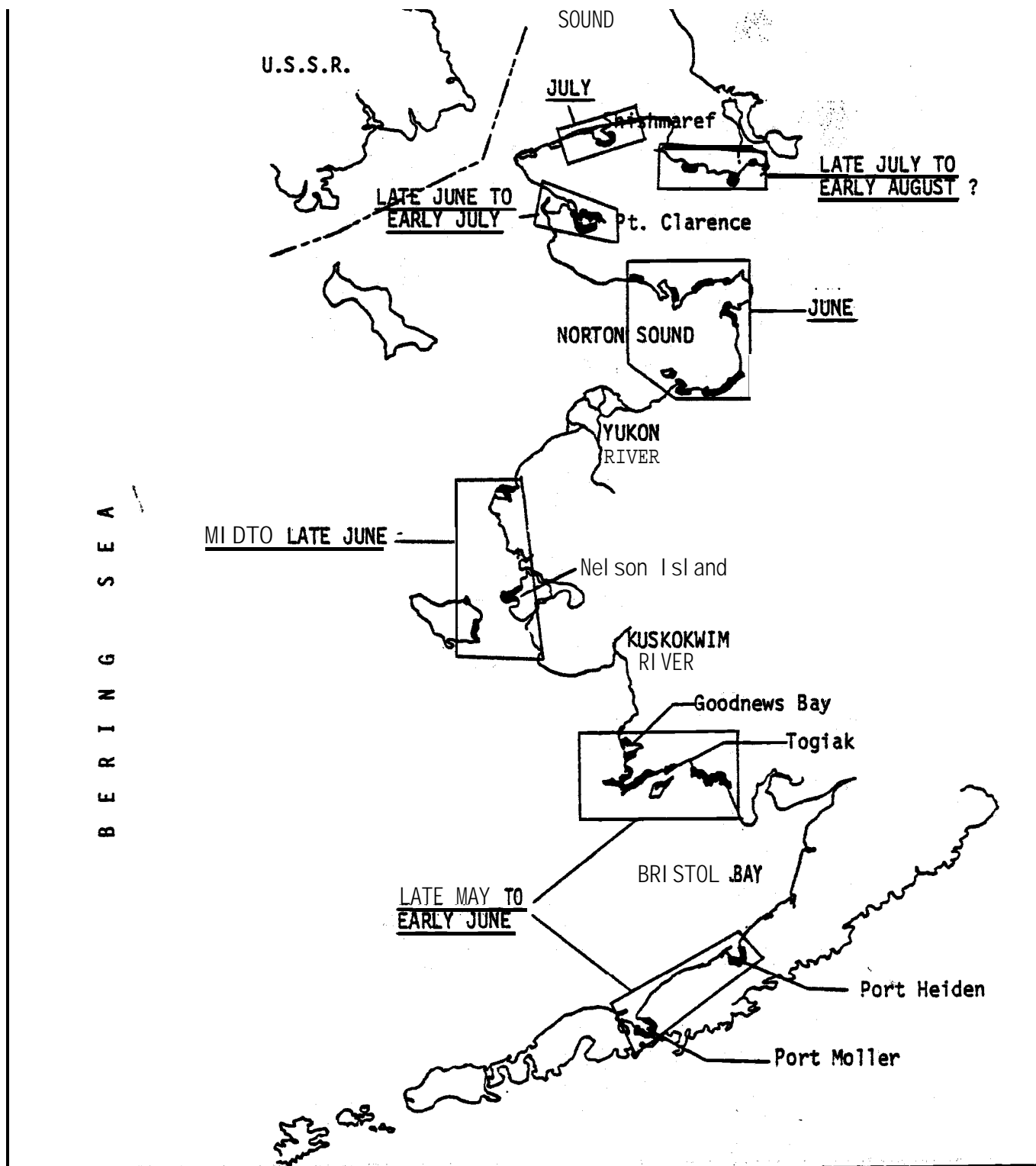


Figure 64 . Timing and distribution of Pacific herring spawning in the eastern Bering Sea.

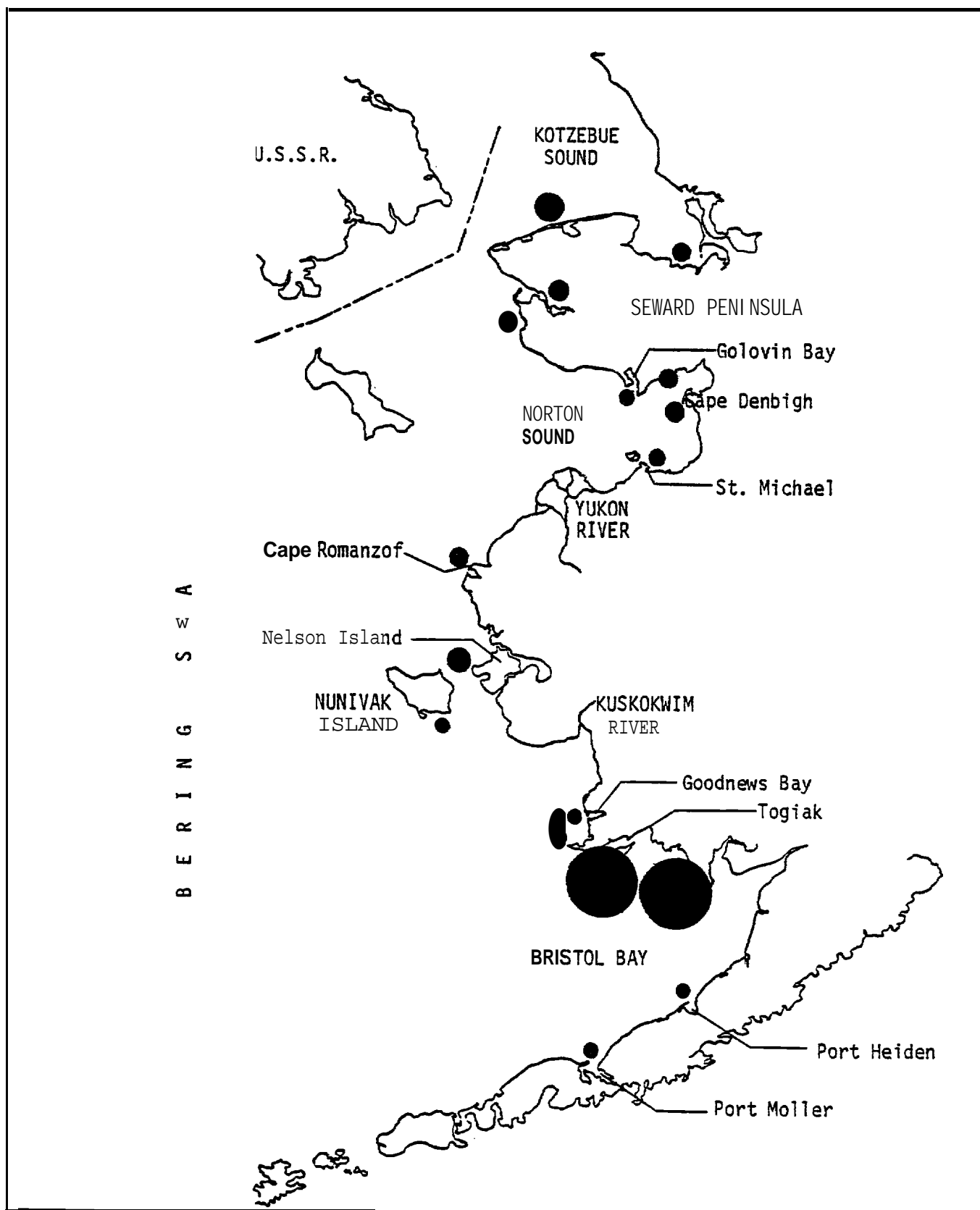


Figure 65 . Relative abundance of Pacific herring based upon peak count surface area estimates of schools observed during aerial surveys, 1976 and 1977.

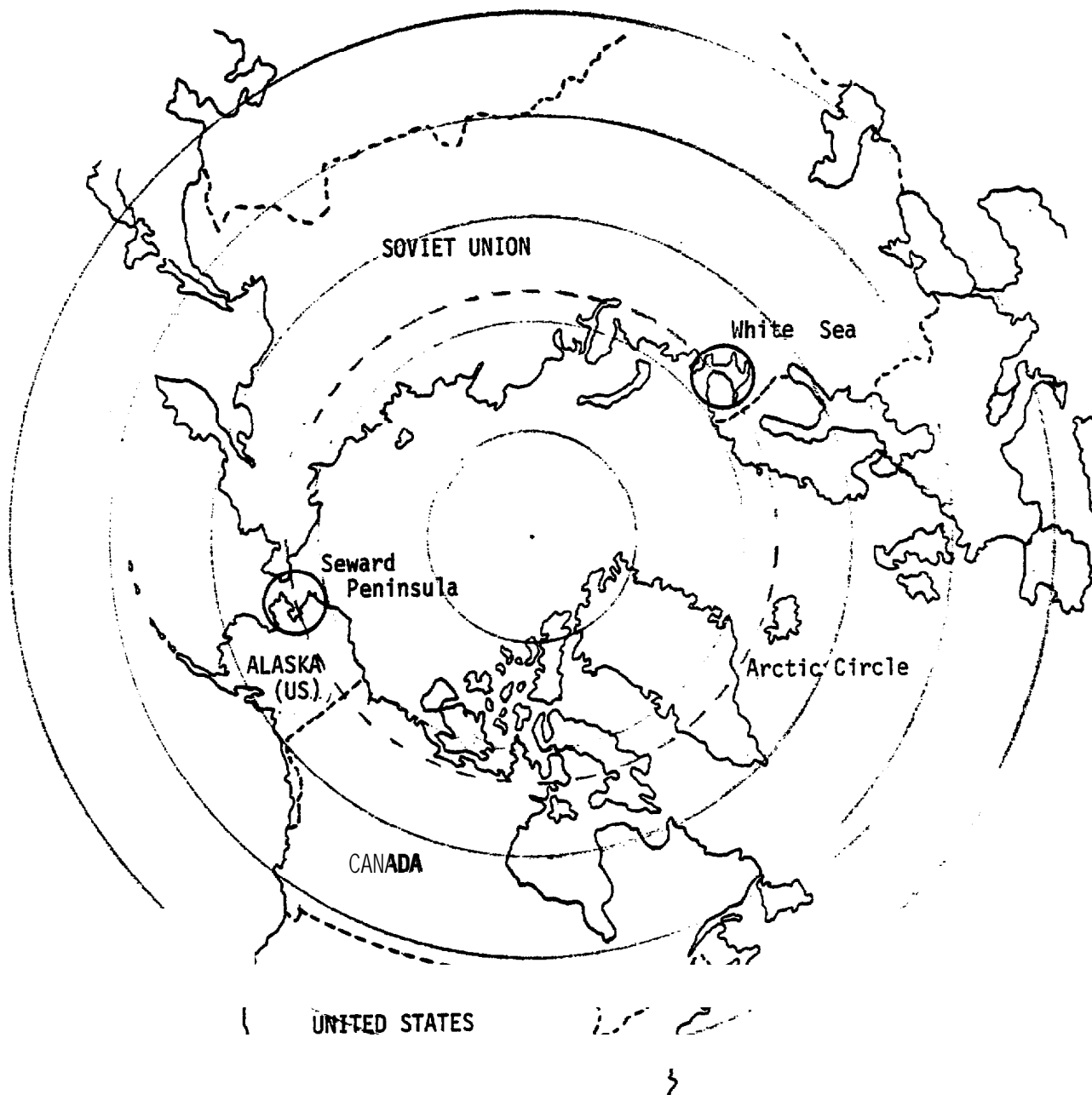


Figure 66. Comparative latitude of the Seward Peninsula and Kotzebue Sound with the White Sea.

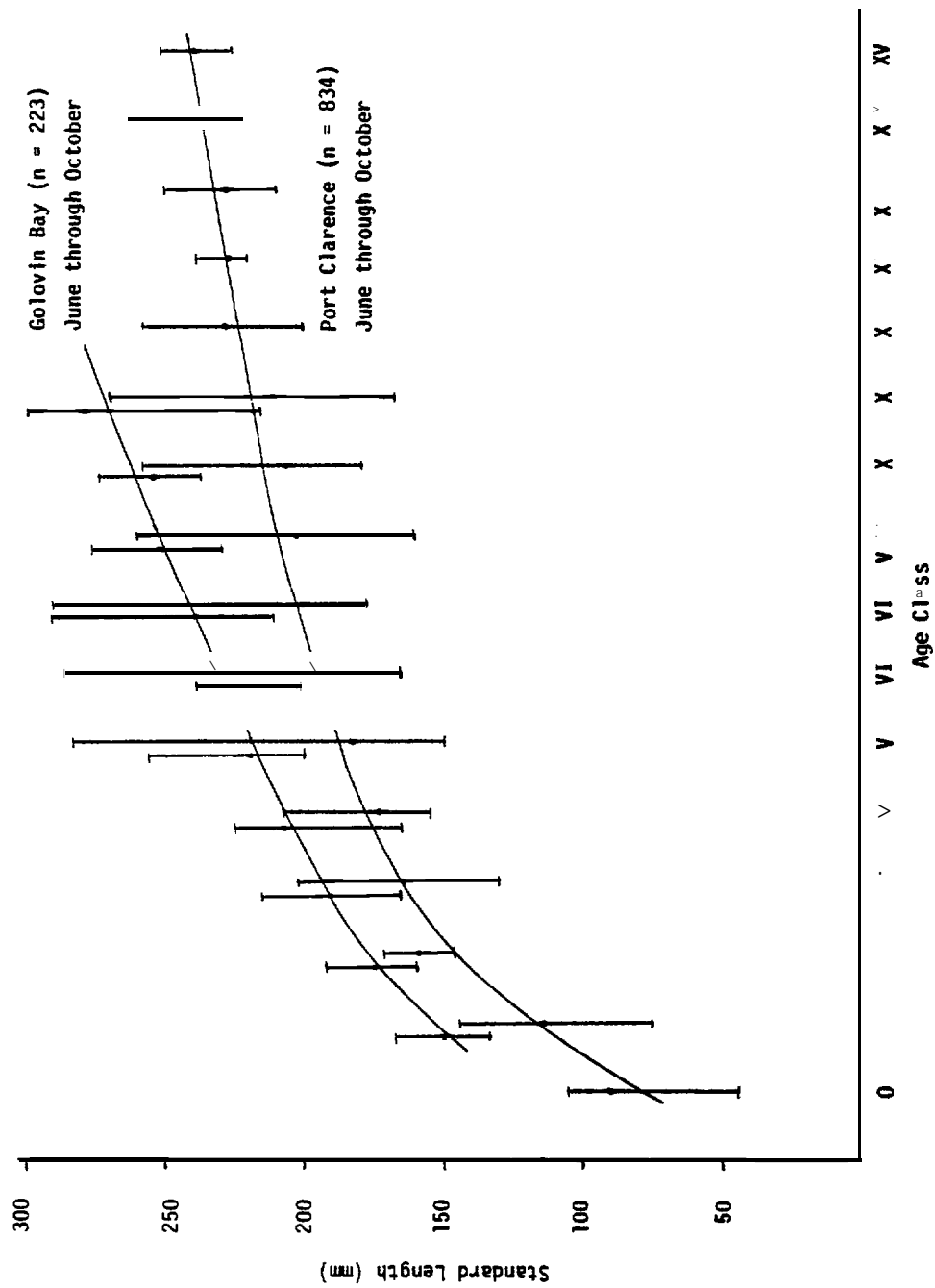


Figure 67. Comparison of mean lengths-at-age for herring sampled in Golovin Bay and the Port Clarence area in 1977. Mean lengths are shown with ranges.

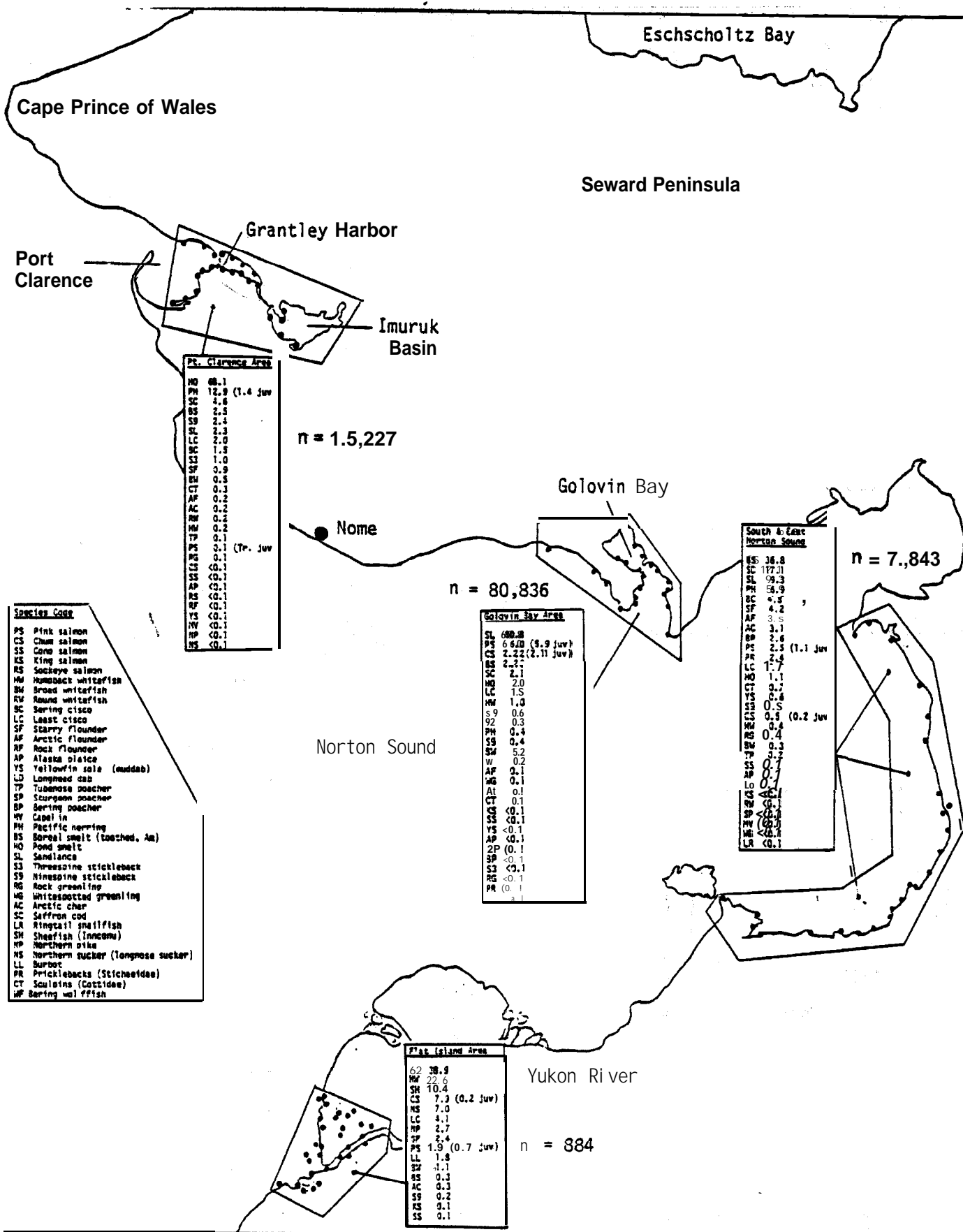
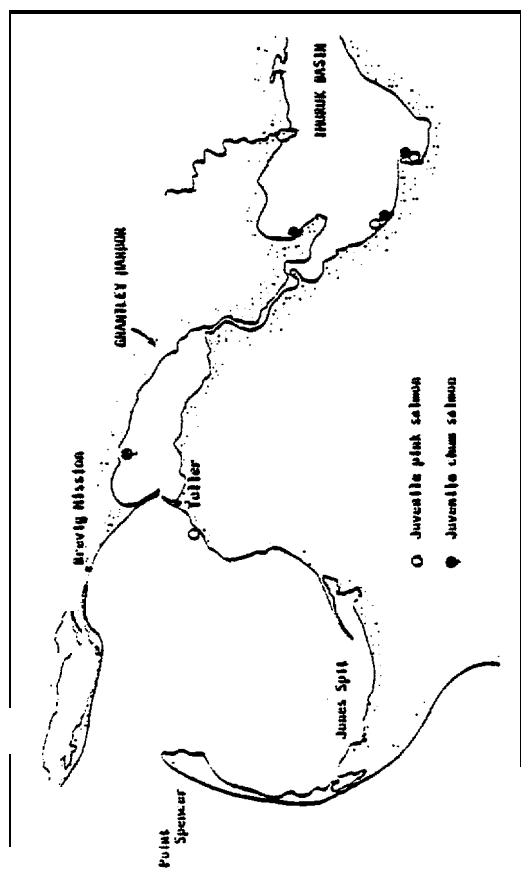
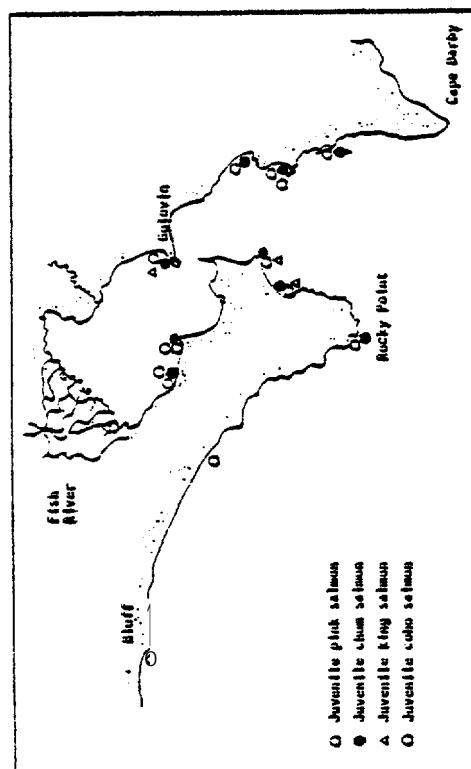


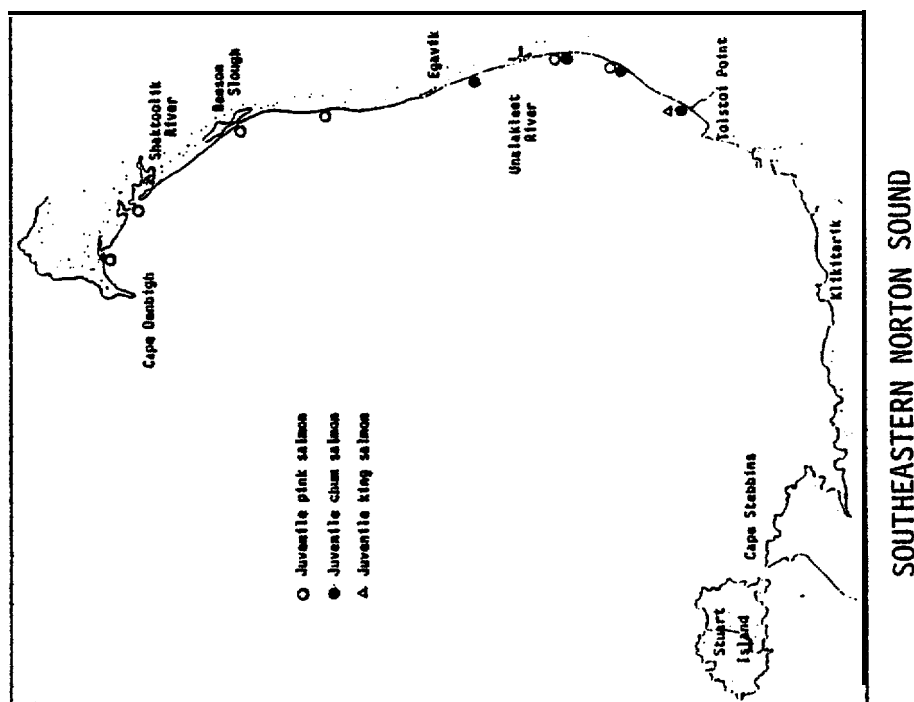
Figure 68. Relative abundance in percent composition of finfish captured throughout the nearshore waters of Norton Sound, 1976-77.



PORT CLARENCE

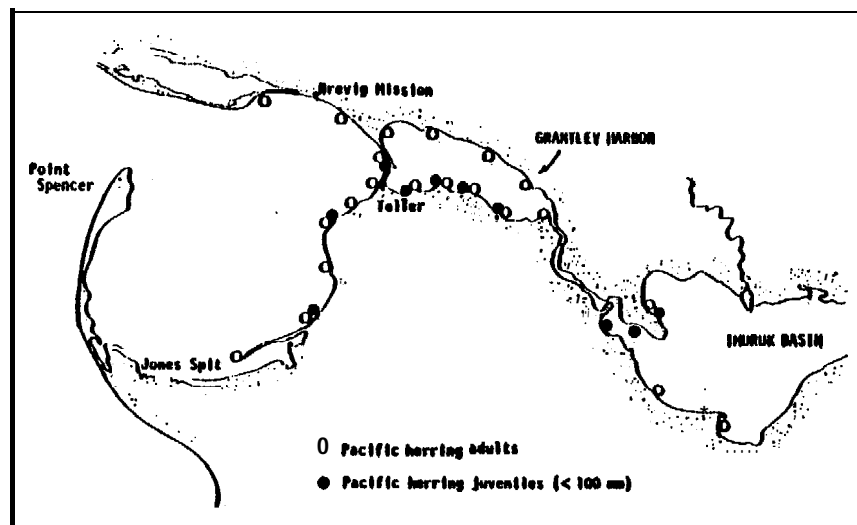


GOLOVIN BAY

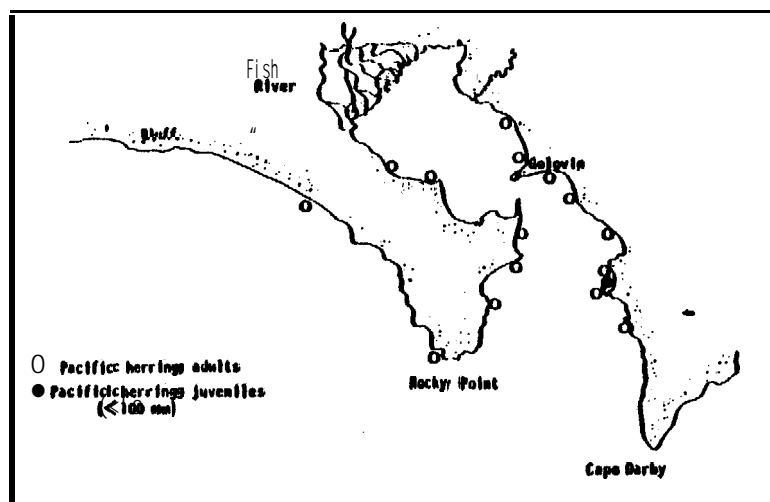


SOUTHEASTERN NORTON SOUND

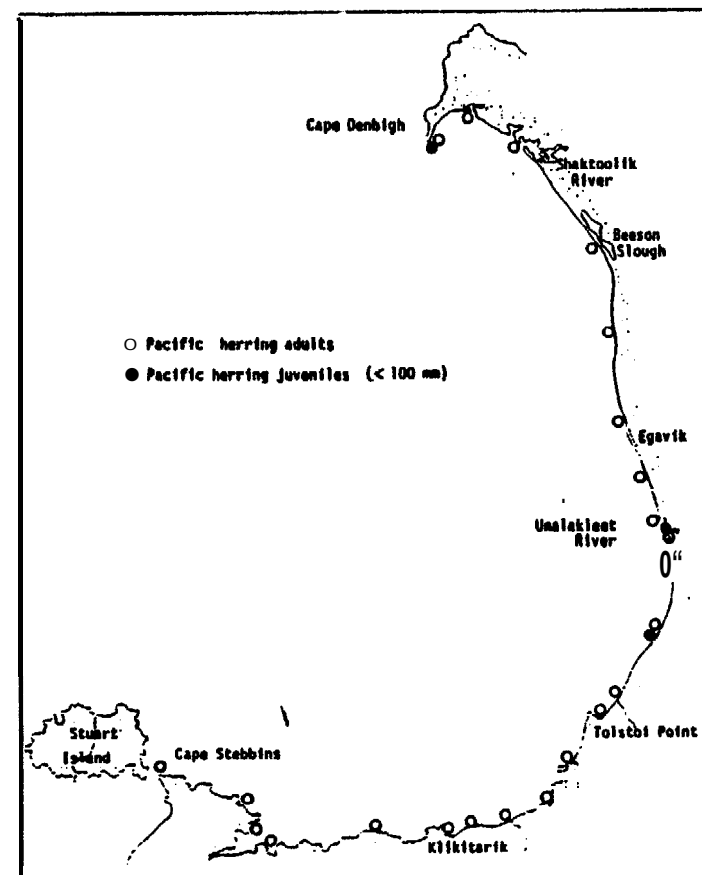
Figure 69. Distribution of juvenile salmon within the study area, 1976-77.



PORT CLARENCE

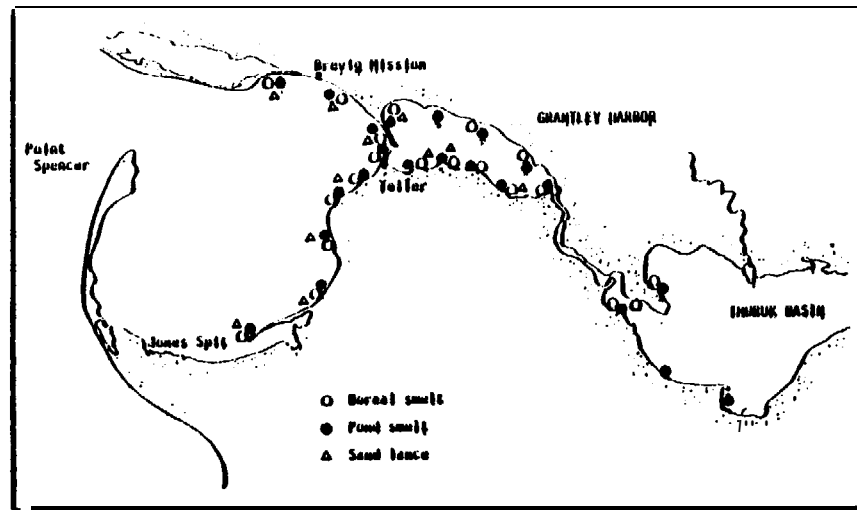


GOLOVIN BAY

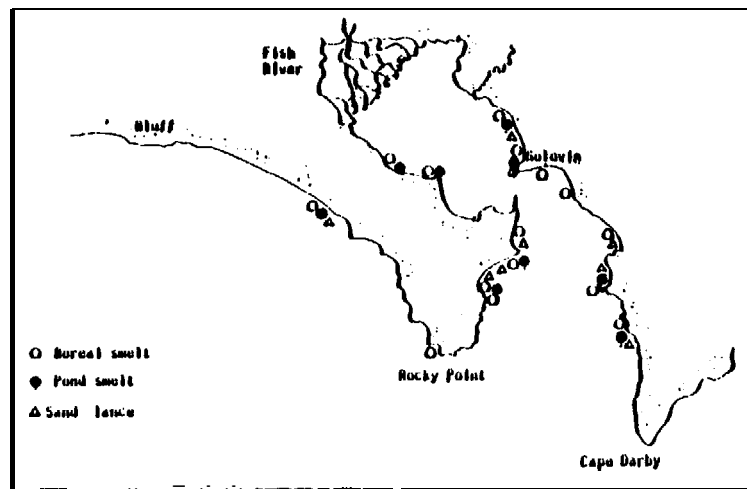


SOUTHEASTERN NORTON SOUND

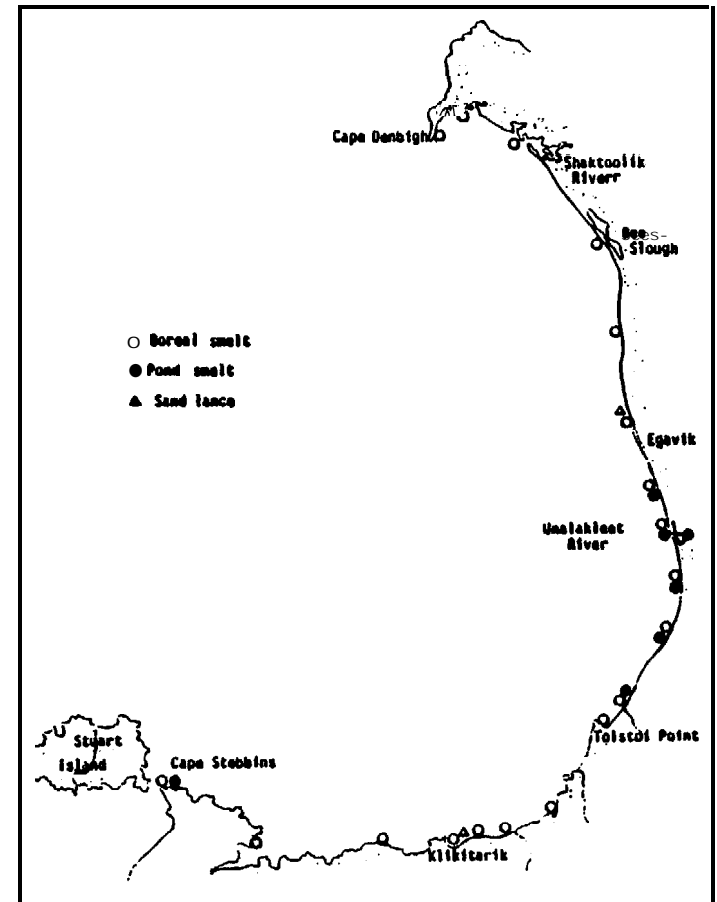
Figure 70. Distribution of Pacific herring within the study area, 1976-77.



PORT CLARENCE

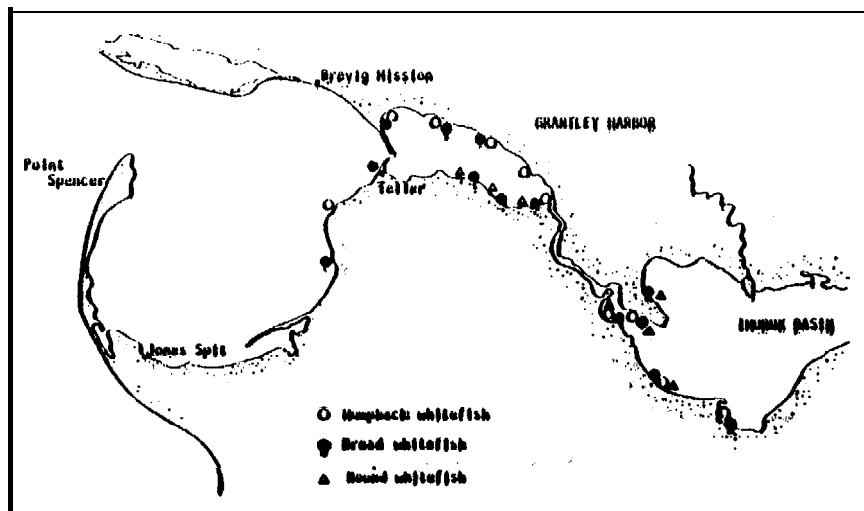


GOLOV IN BAY

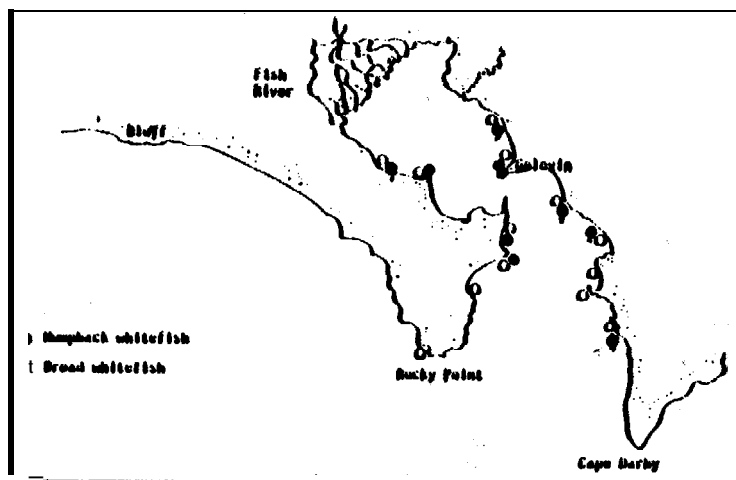


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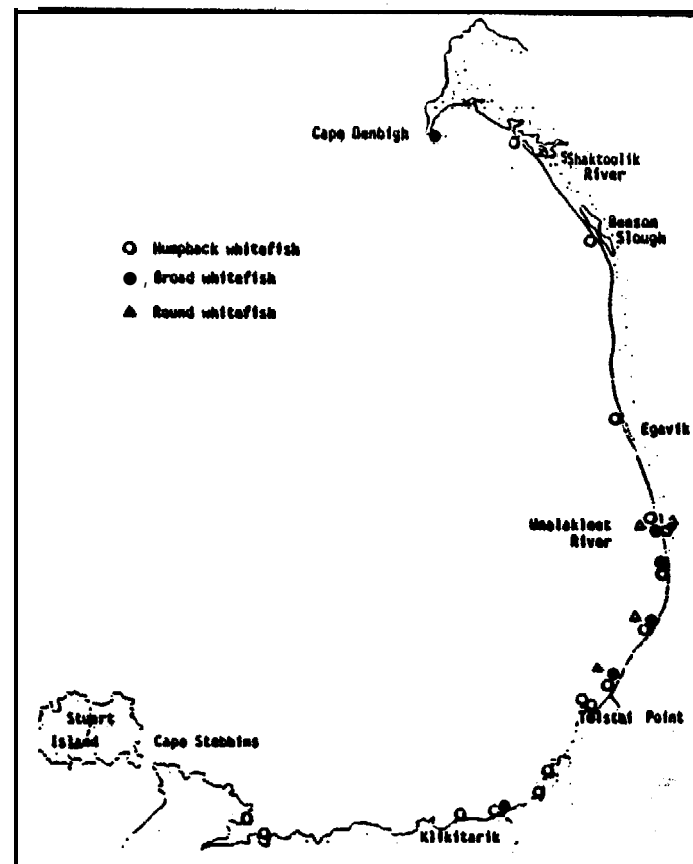
Figure 71. Distribution of boreal and pond smelt and sand lance within the study area, 1976-77,



PORT CLARENCE

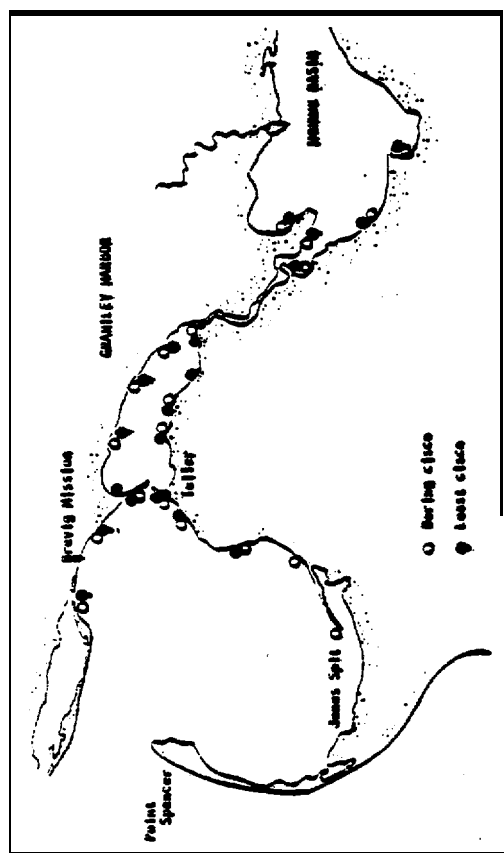


GOLOVIN BAY

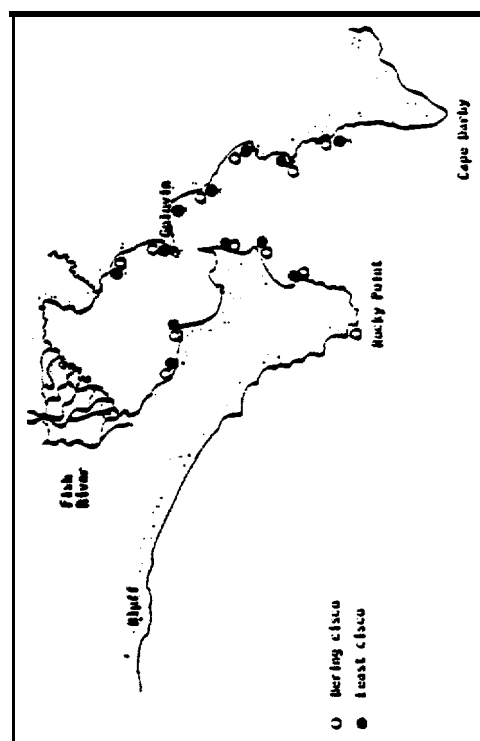


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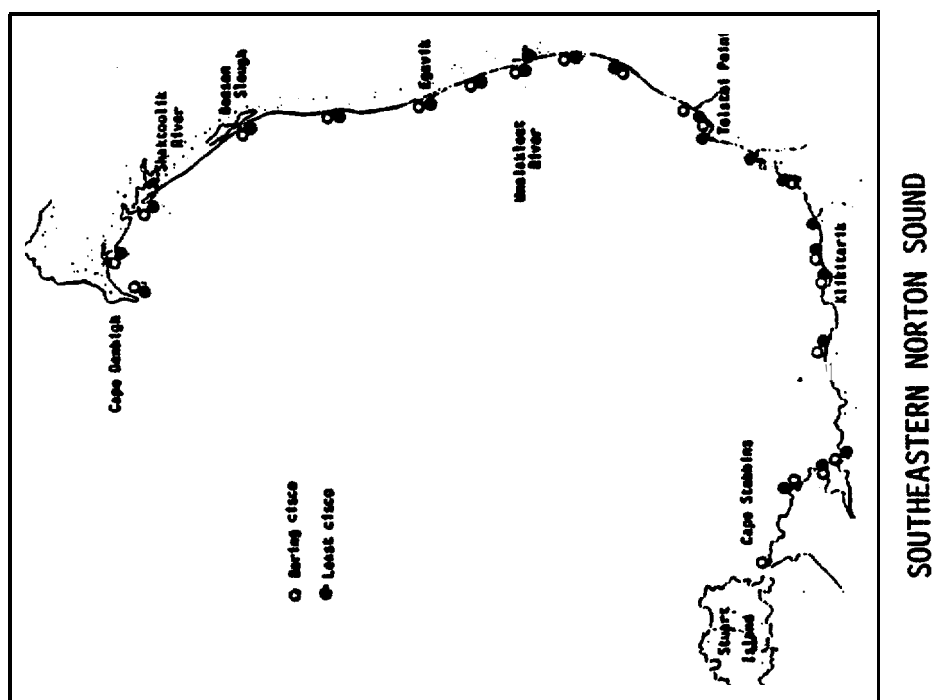
Figure 72. Distribution of humpback, broad and round whitefish within the study area, 1976-77,



PORT CLARENCE

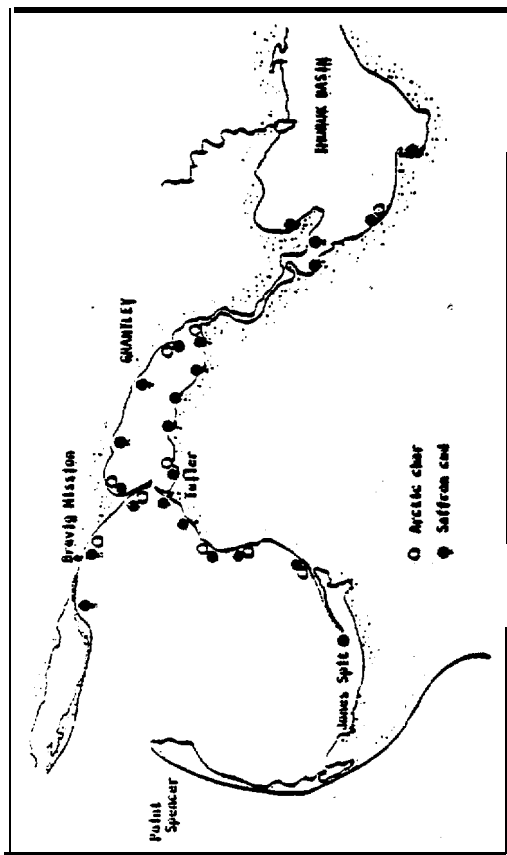


GOLOVIN BAY

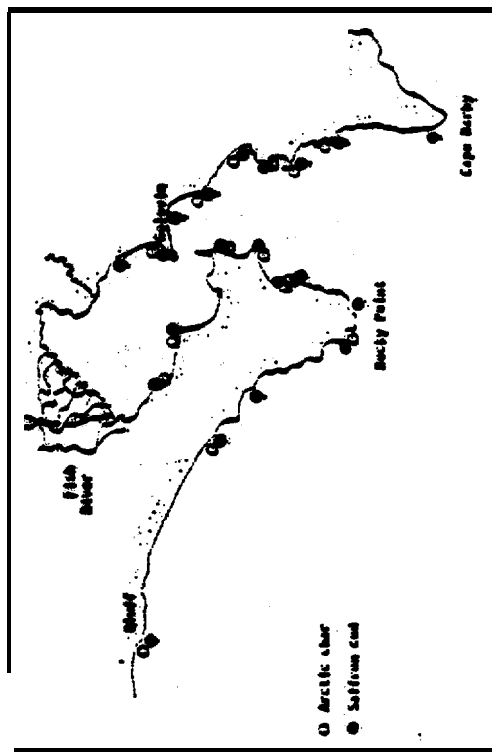


SOUTHEASTERN NORTON SOUND

Figure 73. Distribution of Bering and least cisco within the study area, 1976-77.



PORT CLARENCE



GOLOVIN BAY

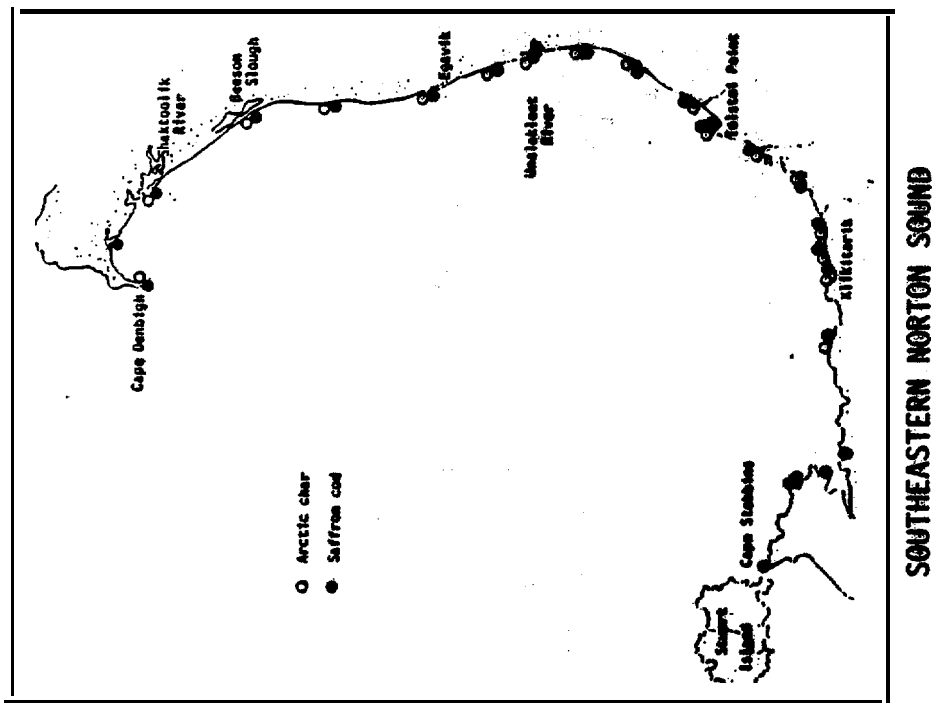


Figure 74. Distribution of Arctic char and saffron cod within the study area, 1976-77.

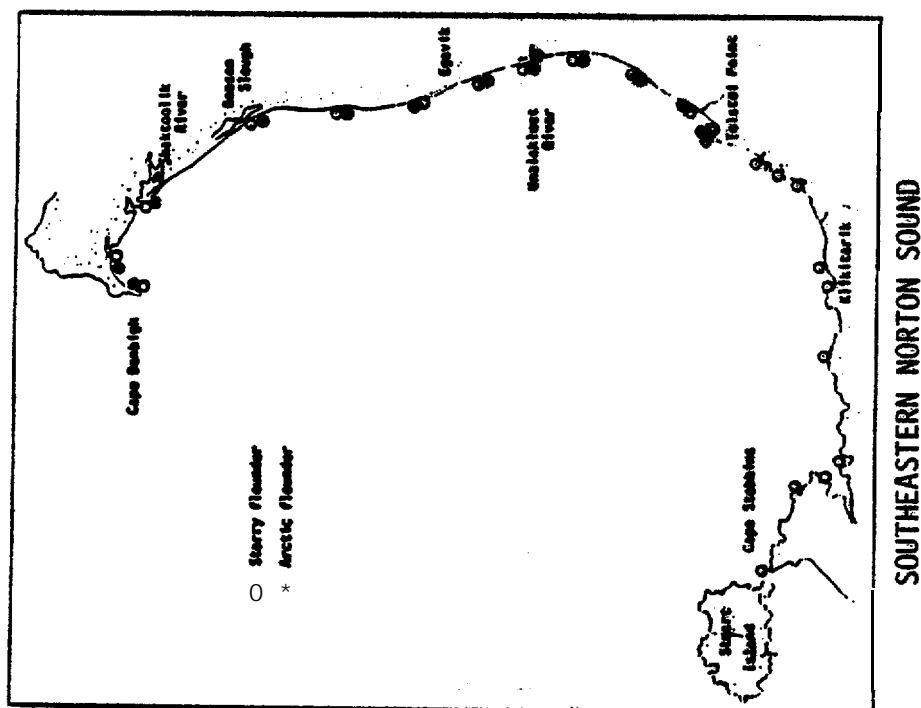
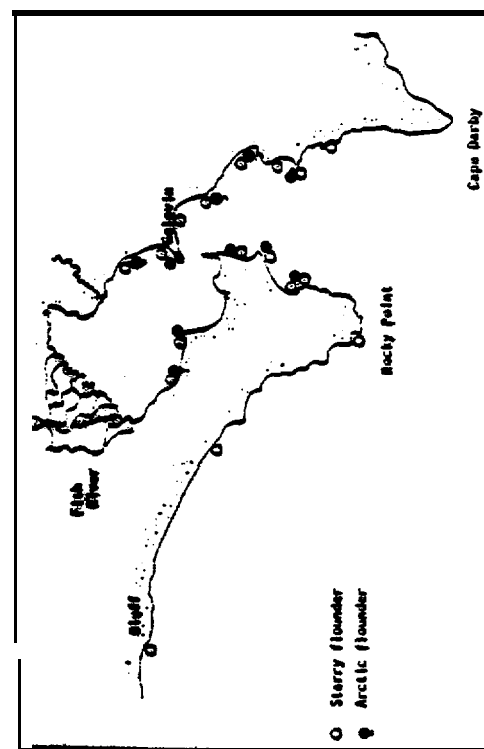
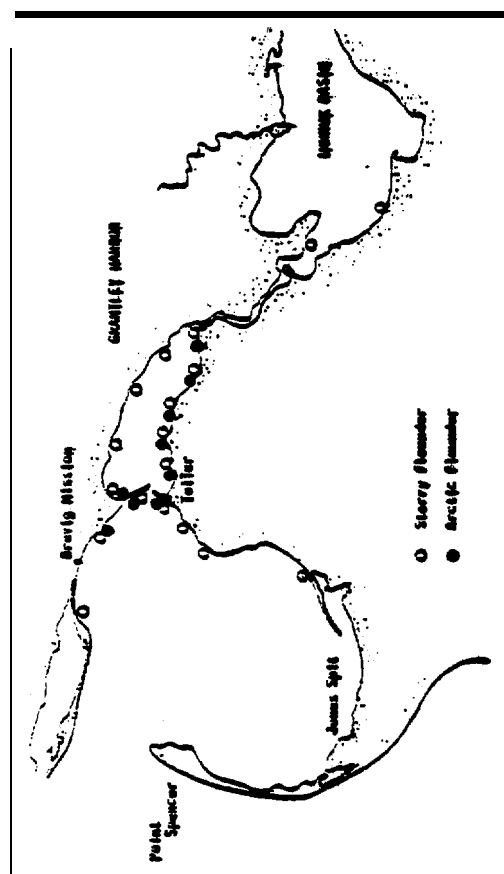
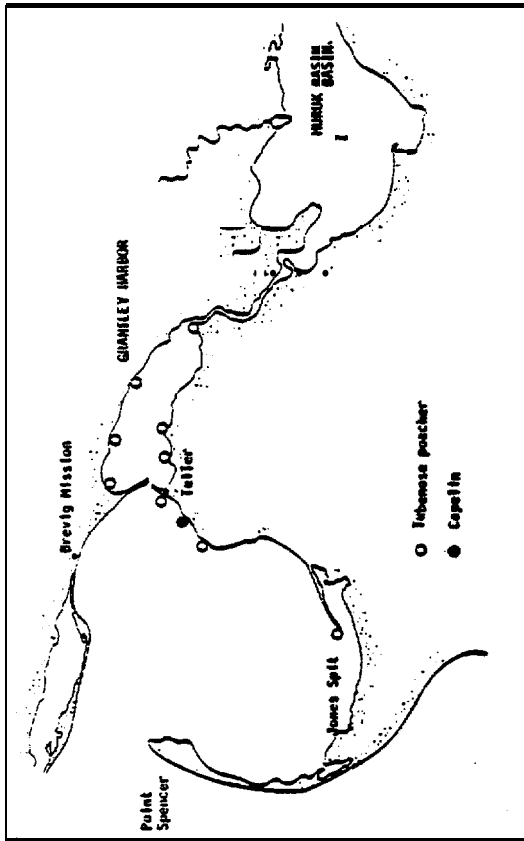
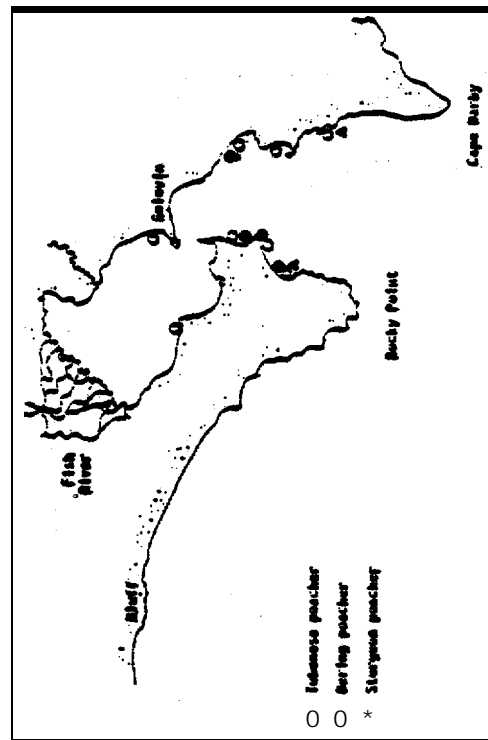


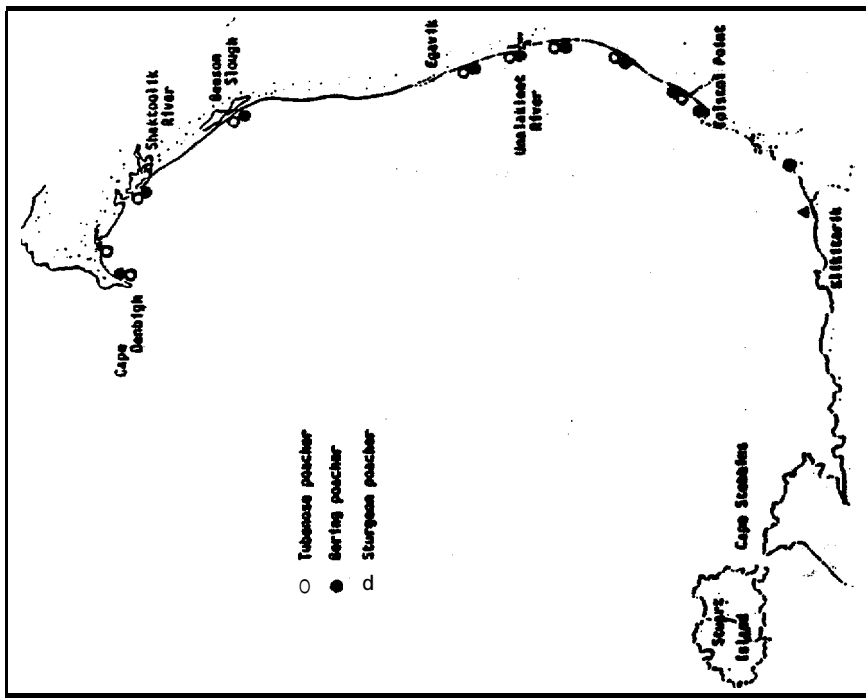
Figure 75 Distribution of starry flounder and Arctic flounder within the study area, 1976-77.



PORT CLARENCE



GOLOVIN BAY



SOUTHEASTERN NORTON SOUND

Figure 76. Distribution of sea poachers within the study area, 1976-77.

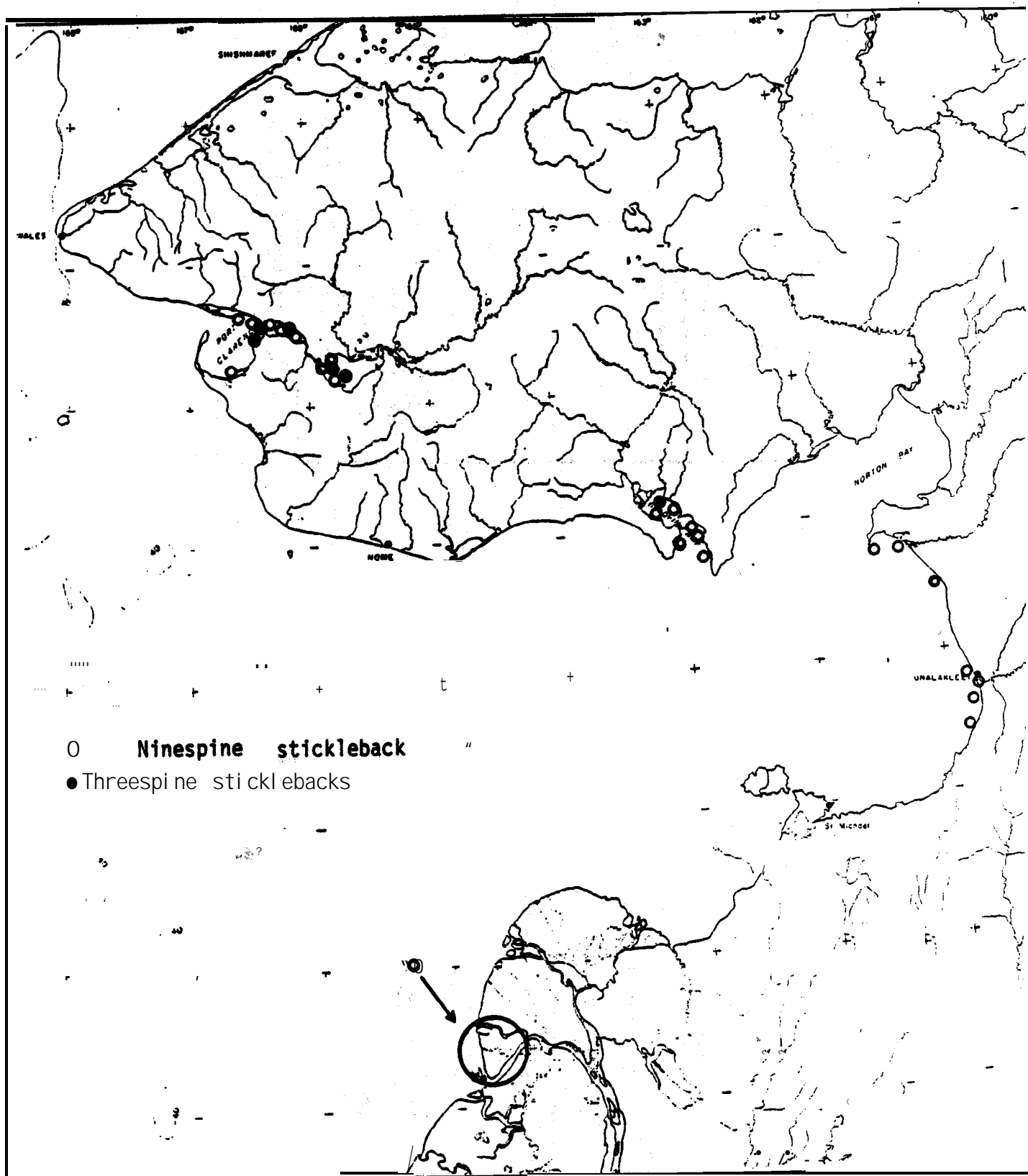


Figure 77. Distribution of **ninespine** and threespine sticklebacks within the study area 1976-77.

- Alaska Plaice
- Yellowfin sole
- △ Longhead dab

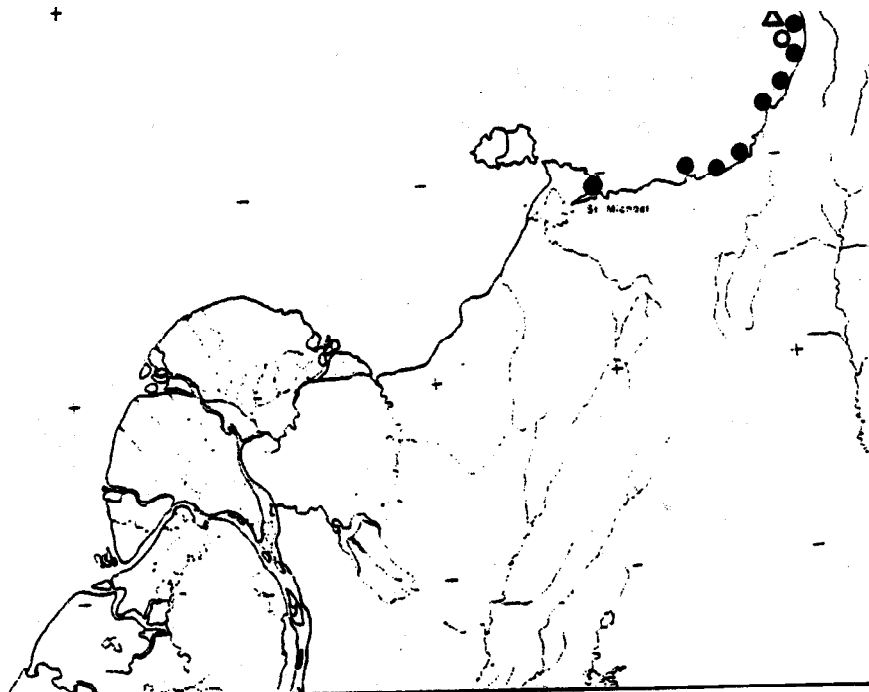


Figure 78. Distribution of Alaska plaice, **yellowfin** sole and longhead dab within the study area, 1976-77.

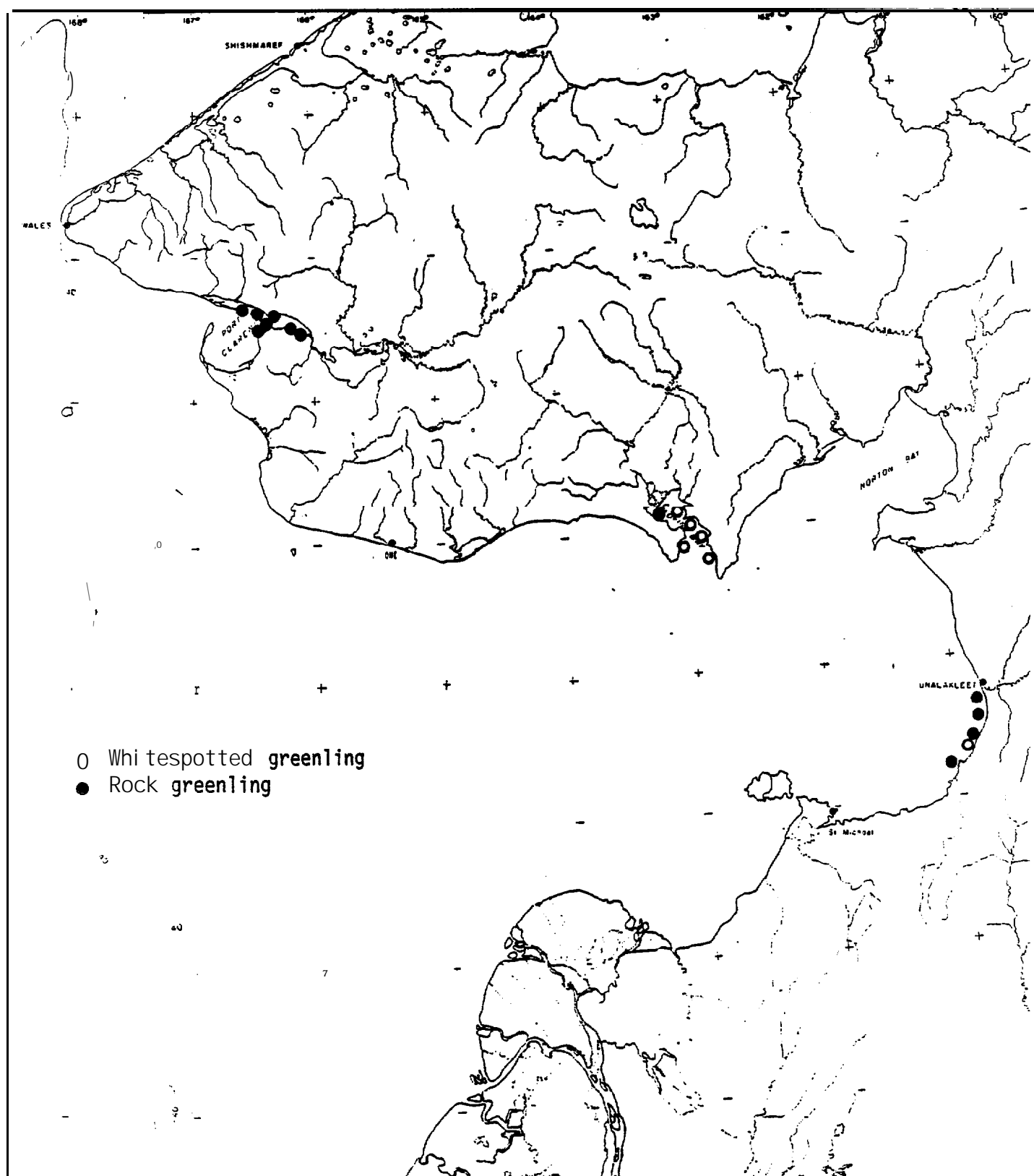


Figure 79. Distribution of whitespotted and rock greenling within the study area, 1976-77.

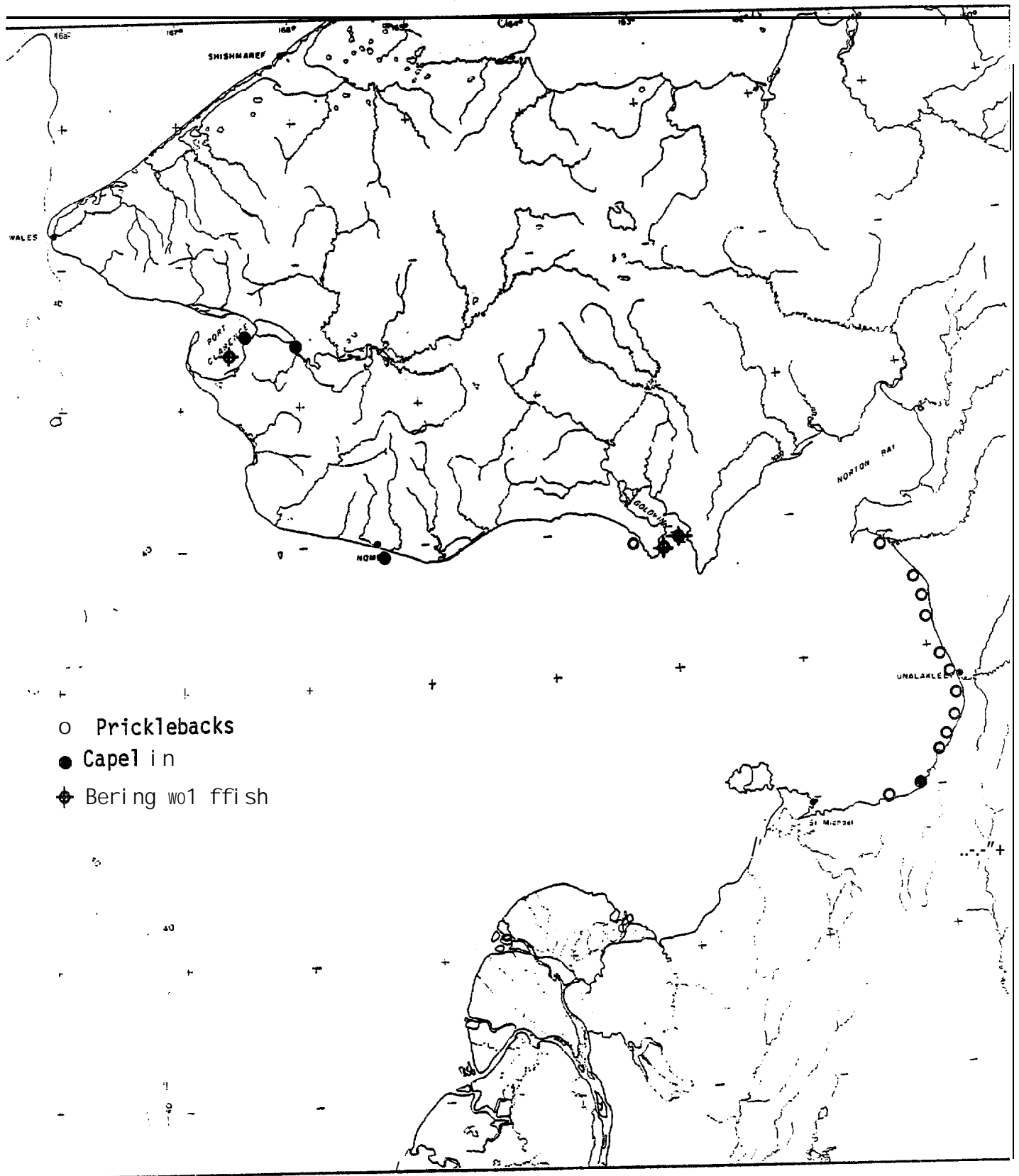


Figure 80. Distribution of **pricklebacks**, **capelin** and **Bering wolffish** within the study area, 1976-77.

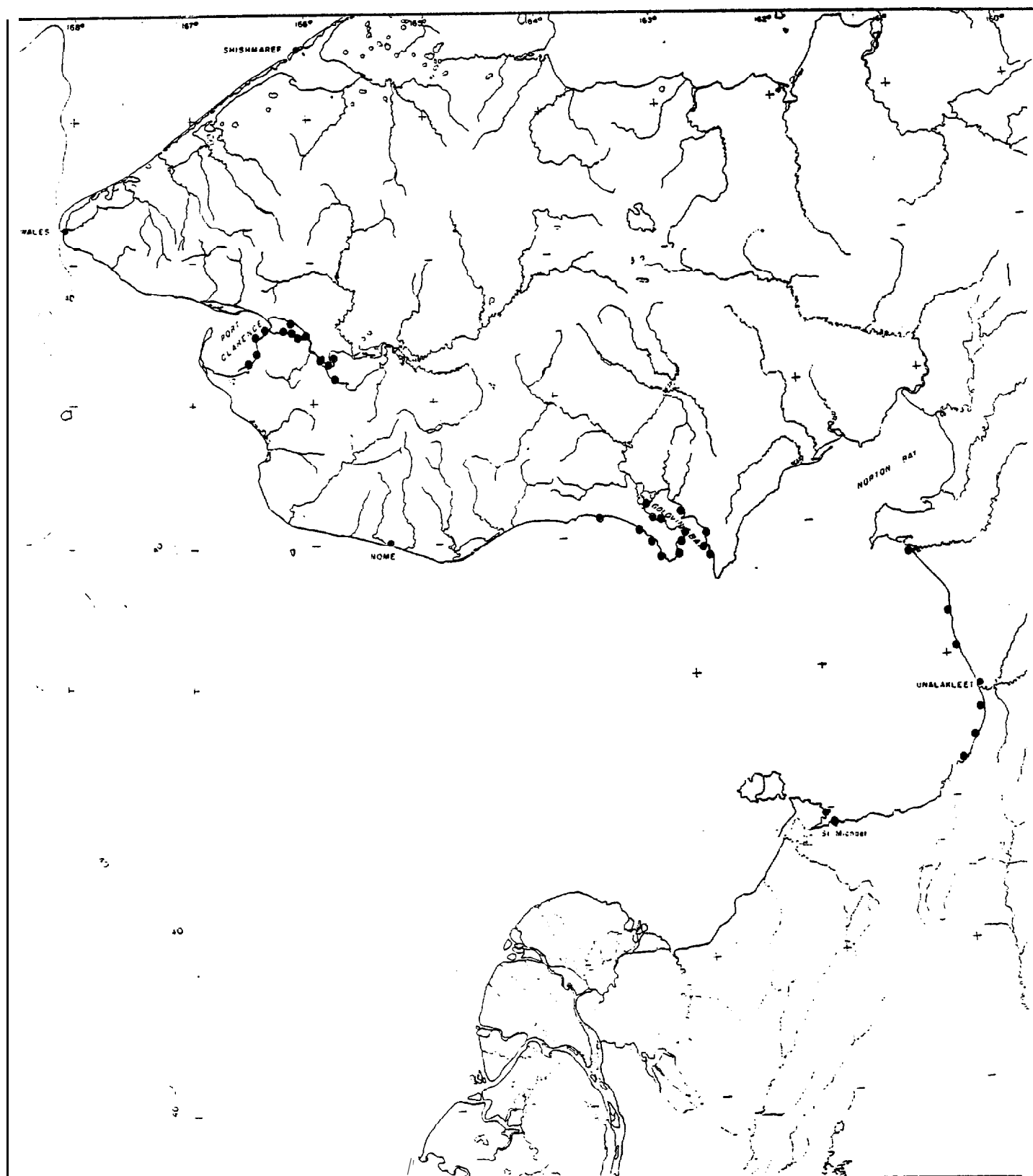


Figure 81. Distribution of larval boreal smelt in coastal waters within the study area, 1976-77.

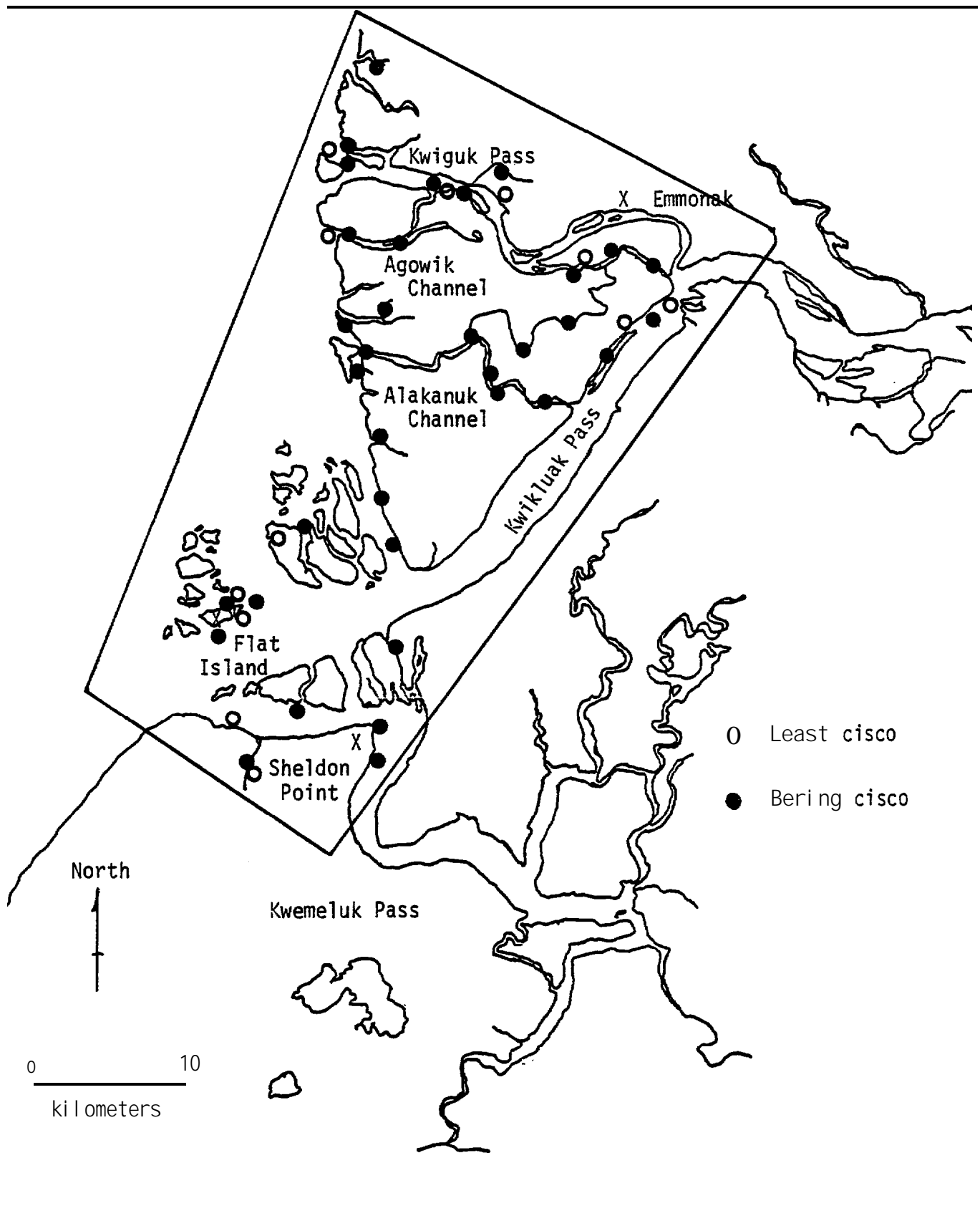


Figure 82. Distribution of least cisco and Bering cisco catches at the south mouth of the Yukon River, June 9 through August 5, 1976.

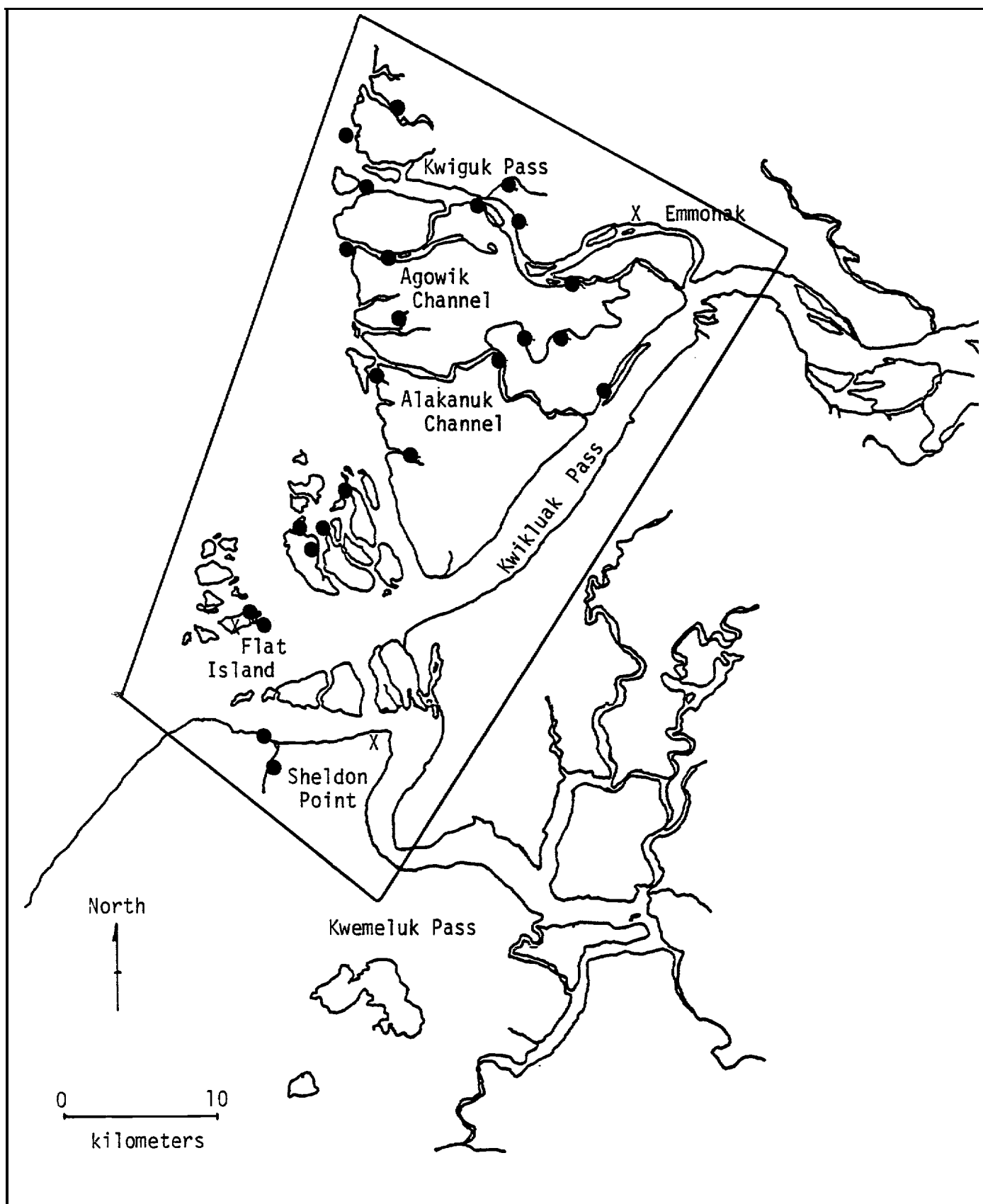


Figure 83. Distribution of humpback whitefish catches at the south mouth of the Yukon River, June 9 through August 5, 1976.

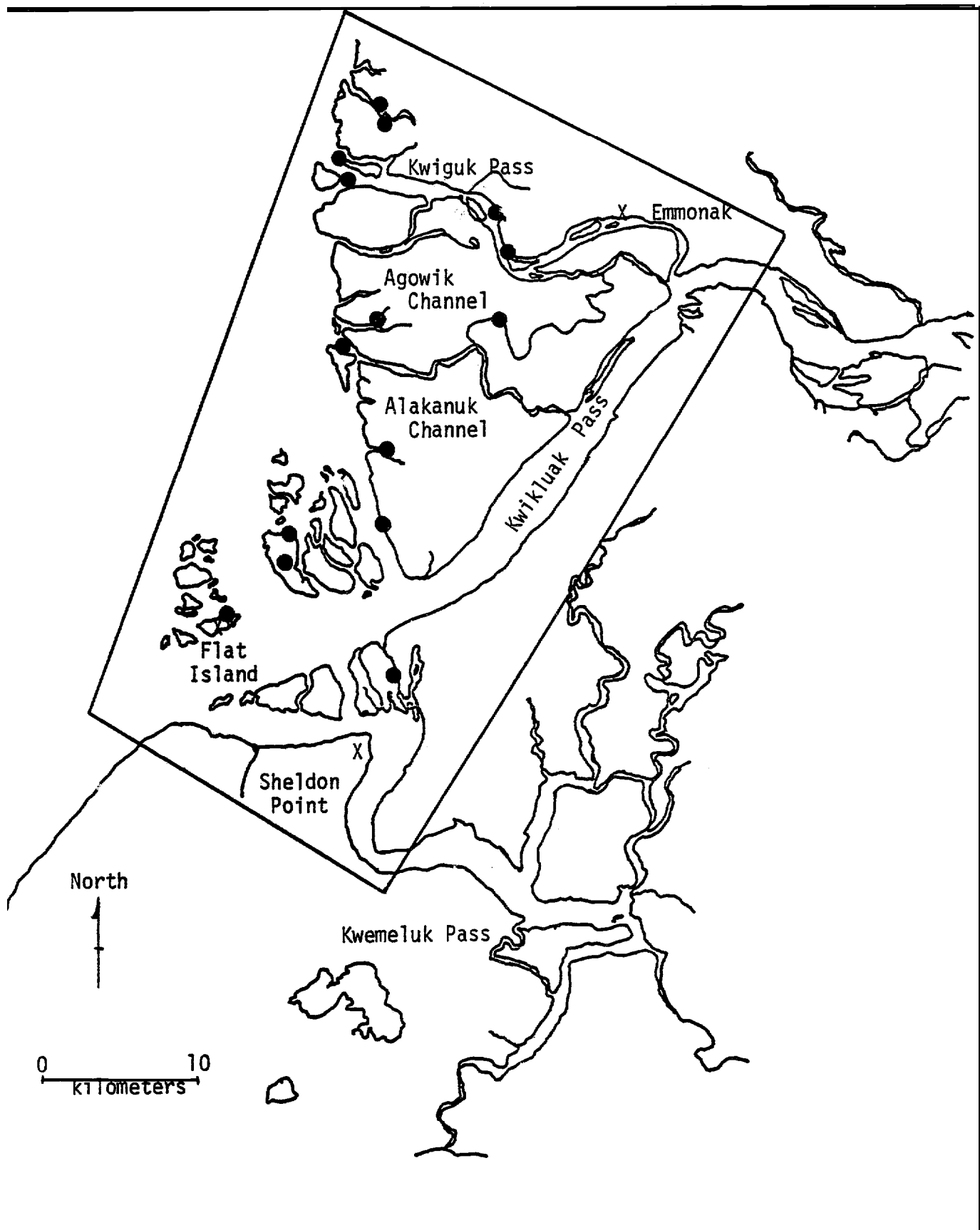


Figure 84. Distribution of **sheefish (*Inconnu*)** catches at the south mouth of the Yukon River, June 9 through August 5, 1976.

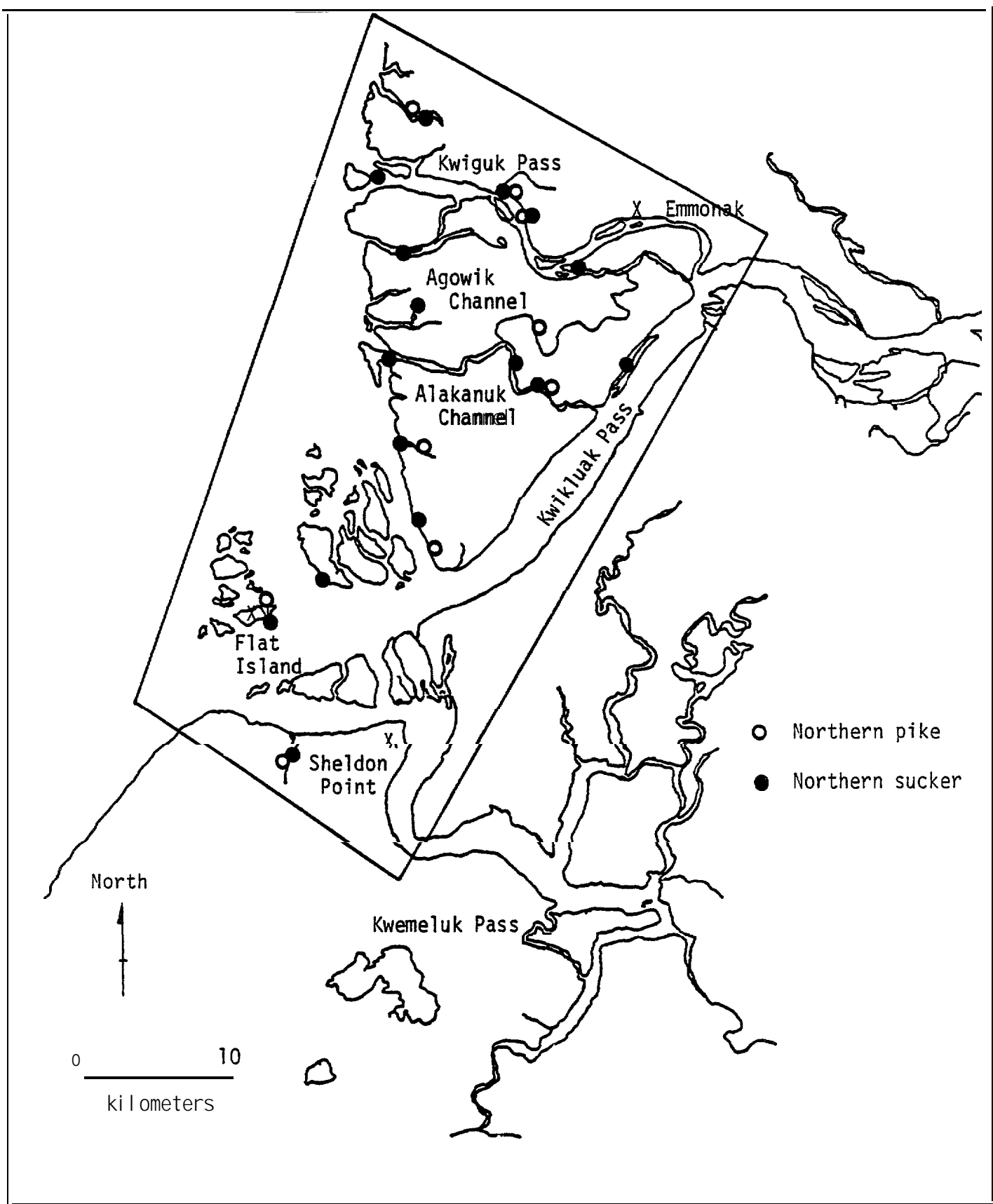


Figure 85. Distribution of northern pike and northern sucker catches at the south mouth of the Yukon River, June 9 through August 5, 1976.

APPENDIX X PHOTOGRAPHS



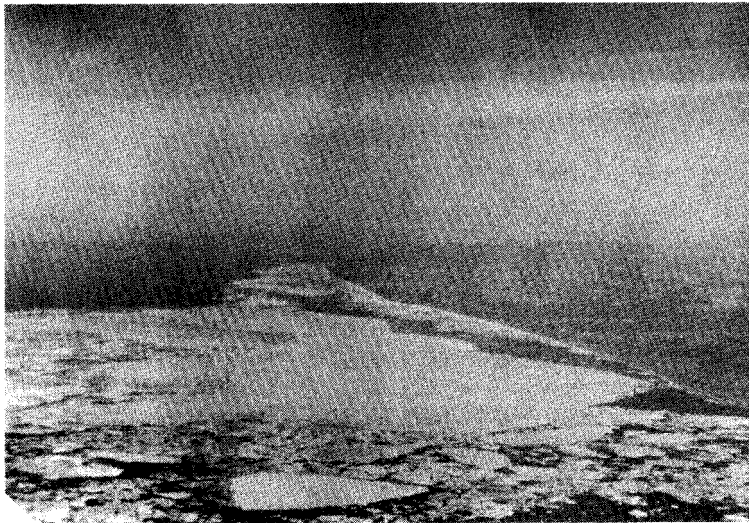
1. Norton Sound ice conditions, June 10, 1976. Looking, east at Cape Stebbins.



2. Ice conditions at Klikitarik, June 10, 1976. Three weeks of coastal sampling was lost immediately following spring breakup in Norton Sound in 1976 due to a delay in project funding.



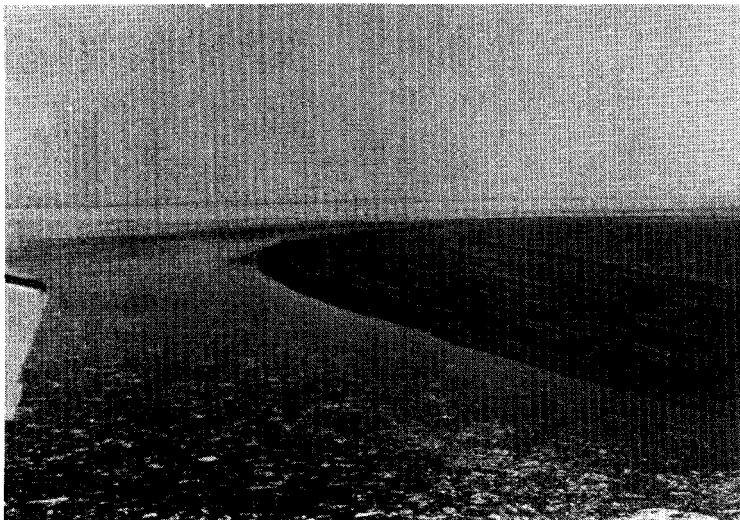
3. Norton Sound ice conditions, June 3, 1977. Looking west along southern coast toward Klikitarik.



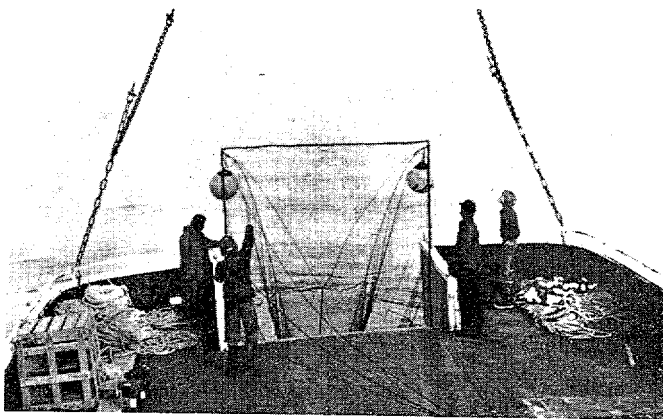
4. Norton Sound ice conditions, June 3, 1977.
Looking north along coast toward Cape Denbigh.



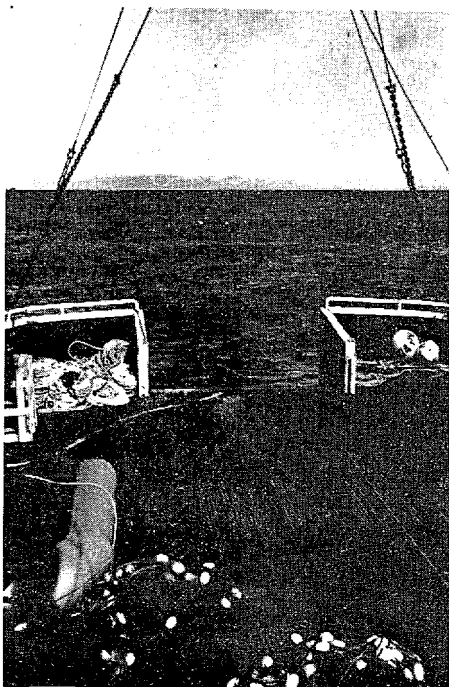
5. Ice conditions in Golovin Bay, June 9, 1977.
Field sampling began in this area on June 9.



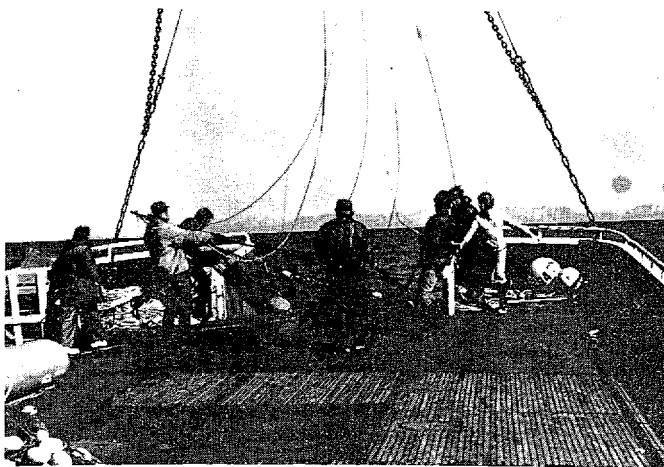
6. Bering Sea pack ice and pan ice conditions at Cape Epsenberg which blocked entry of the *M V Royal Atlantic* into Kotzebue Sound, July 11, 1977.



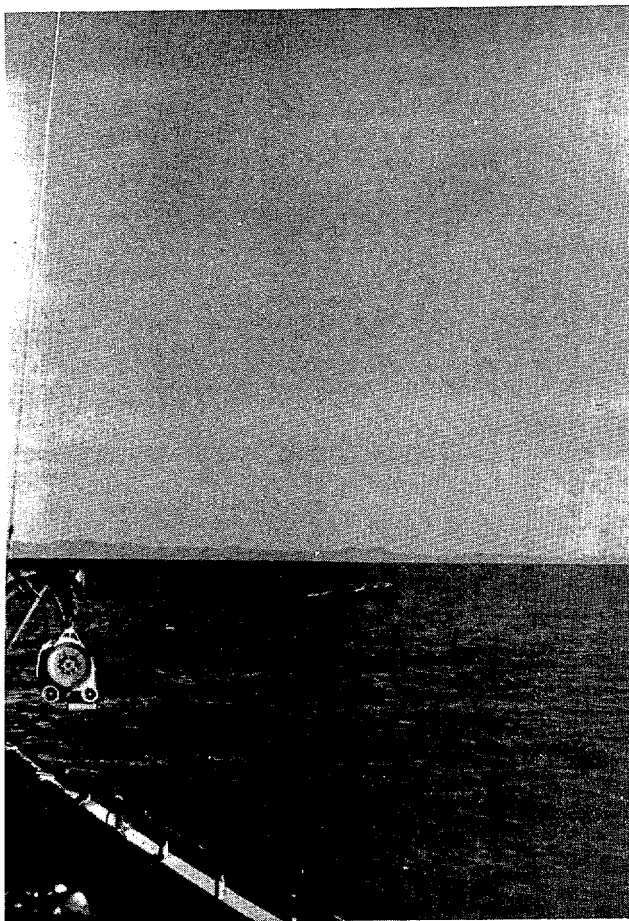
7. Launching the rigid frame surface tow net from the *MV Royal Atlantic* near Tin City, July, 1977.



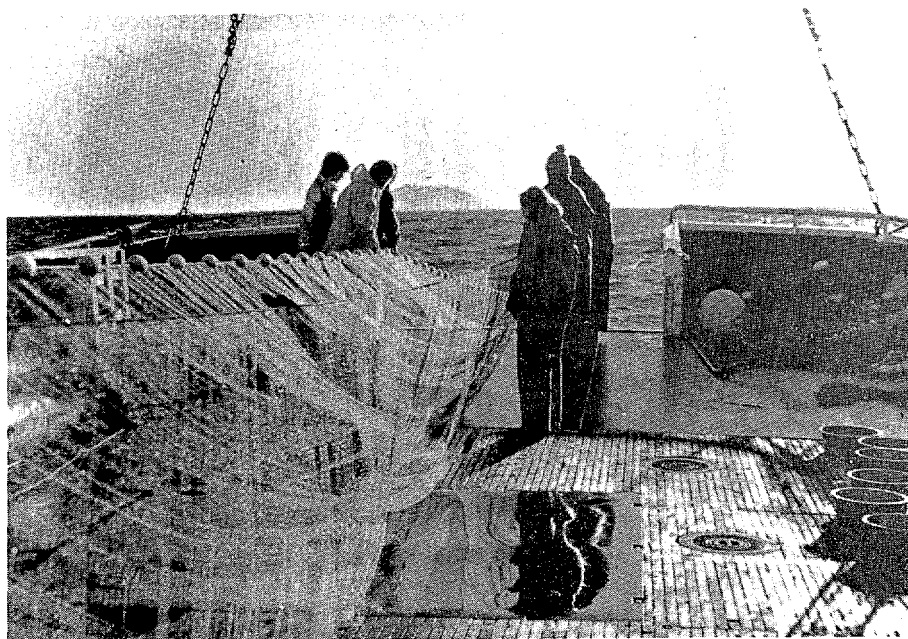
8. Surface tows in Norton Sound were 30 minutes in duration each, and towed at two to three knots.



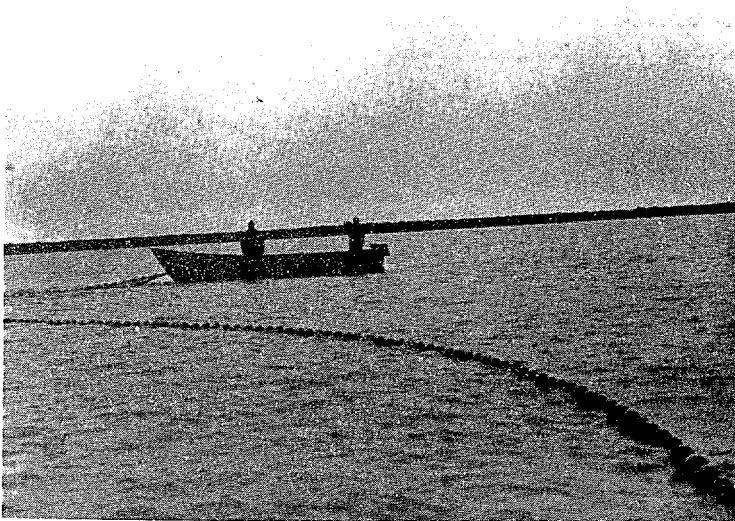
9. Retrieval of tow net. Most catches consisted of larval Osmerics, larval Osmerids, Clupeids or Gadids.



10. Fishing variable mesh, long line gillnets from the MV *Royal Atlantic*, June, 1977. Overnight soaks of 8-10 hours were made daily.



11. Retrieval of variable mesh gillnets aboard the MV *Royal Atlantic*. Catches consisted primarily of Pacific herring.



12. Deployment of 46x7 meters hand purse seine in Yukon River estuary.



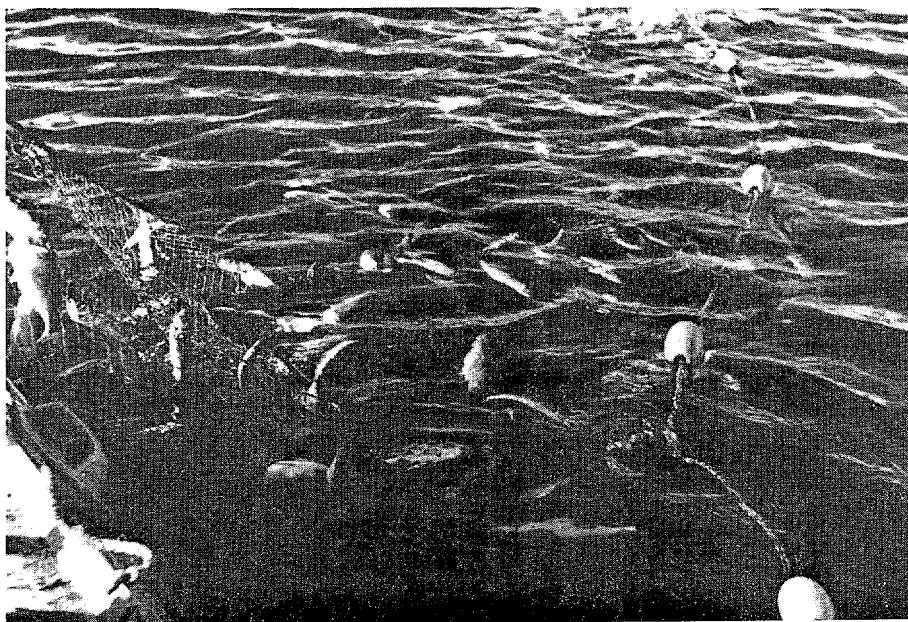
13. Retrieval of the hand purse seine used to sample the Yukon River estuary, 1977.



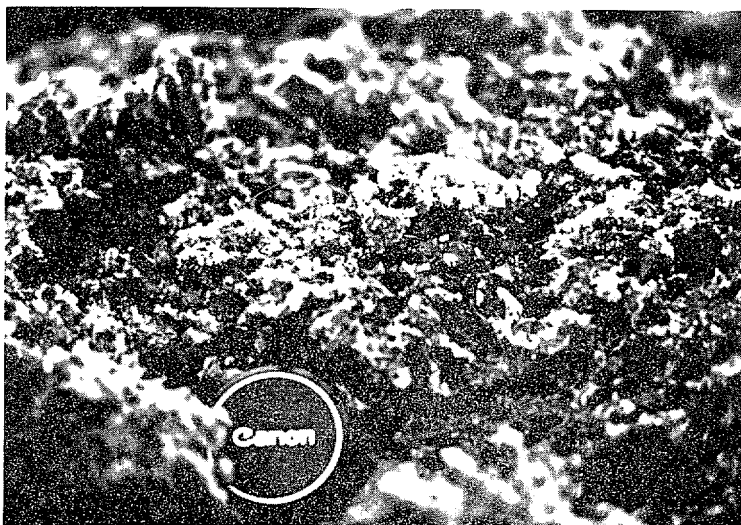
14. Juvenile Coregonids and Salmonids were among the most frequently captured species with the 3 mm hand purse seine in the Yukon River estuary in June, 1977.



15. Setting one of the many offshore variable mesh gillnets in Golovin Bay, October, 1977.



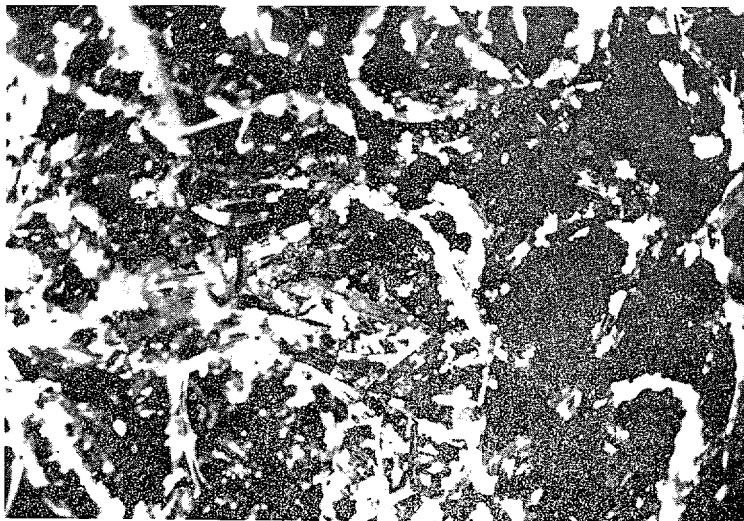
16. Retrieving a floating variable mesh gillnet in Grantley Harbor, July 1977. Catch included more than 600 Pacific herring.



17. Herring spawn on rockweed kelp (*Fucus* sp.). *Fucus* was documented as a major spawning substrate for herring in most areas along the western Alaskan coastline.



18. *Fucus* on exposed rocks near Klikitarik in southern Norton Sound, June 11, 1977. *Fucus* was common to exposed, rocky headlands and most other rocky coastal areas.



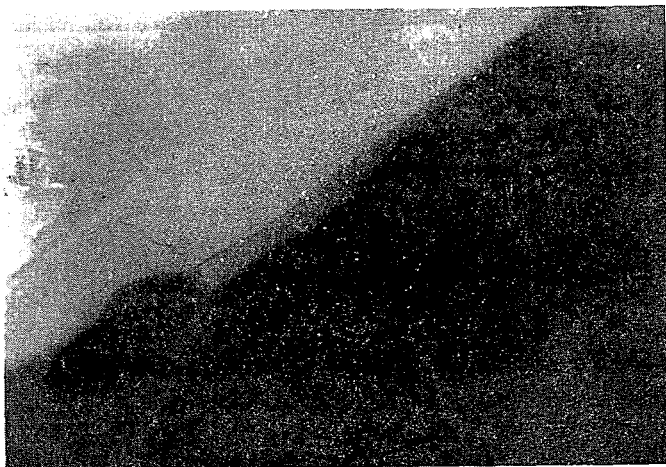
19. A second important spawning substrate for herring was eelgrass (*Zostera* sp.). Eelgrass was common to most shallow secluded bays and inlets.



20. Schools of herring at Fourmile Point in Grantley Harbor, July 21, 1976. Herring occur in dense schools in deep water giving a dark appearance to individual schools.



21. Herring schools at Coyote Creek in Grantley Harbor, July 21, 1976. Fish tend to disperse somewhat in shallow water and schools appear lighter in color. Banding is common under such conditions.



22. School of unidentified fish (believed to be herring) in Shishmaref Inlet, July 21, 1976. Feeding seals and birds were also present.



23. Typical rocky headland characteristic of major herring spawning areas along western Alaska. A white to yellow-white color is produced in the water from milt released by spawning males.



24. A large school of herring entering Shishmaref Inlet, July 1977.



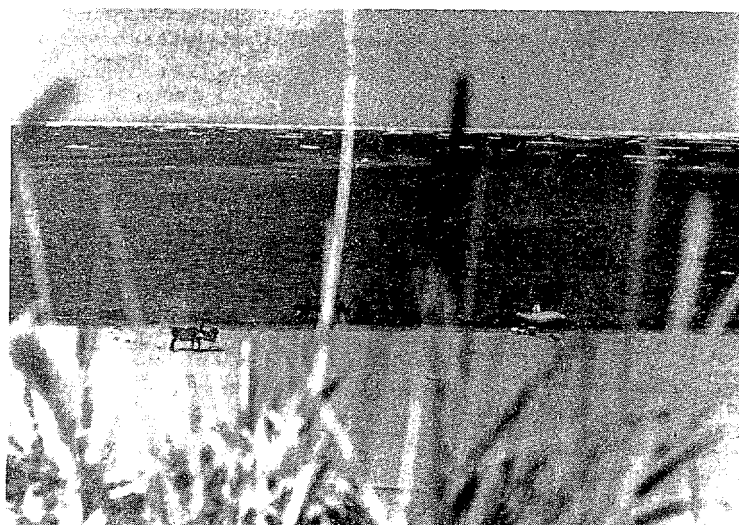
25. Unidentified fish schools (believed to be herring) near Shishmaref, July 1977



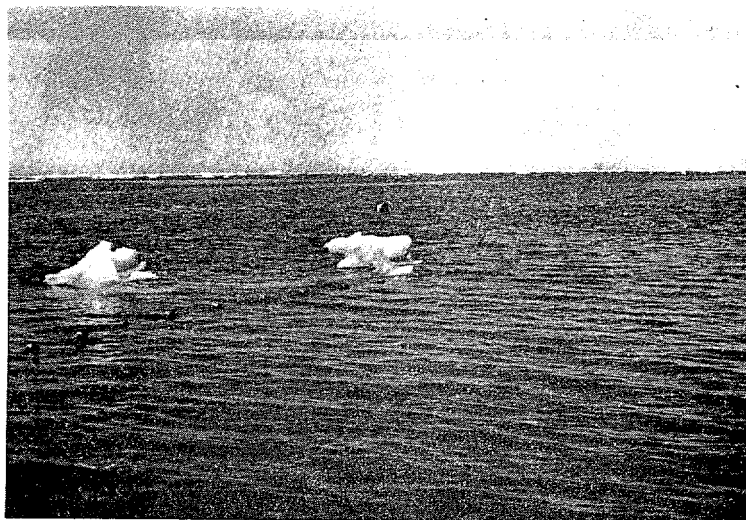
26. Unidentified fish schools in shallow water of Shishmaref Inlet, July 1977.



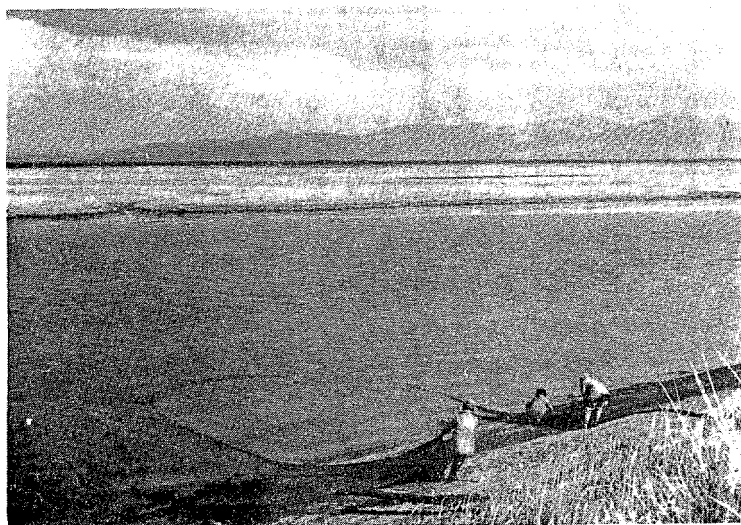
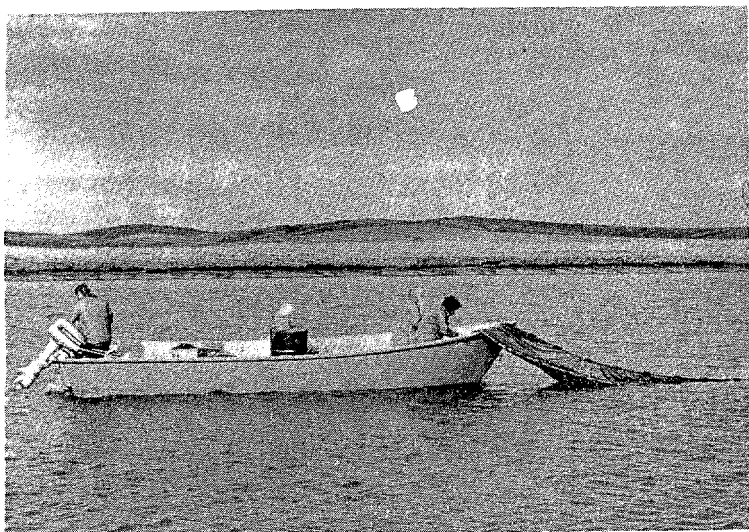
27. Commercial beach seine deployed at Cape Denbigh, June 1977. Approximately nine metric tons of herring were commercially harvested for sac roe production in Norton Sound in 1977.



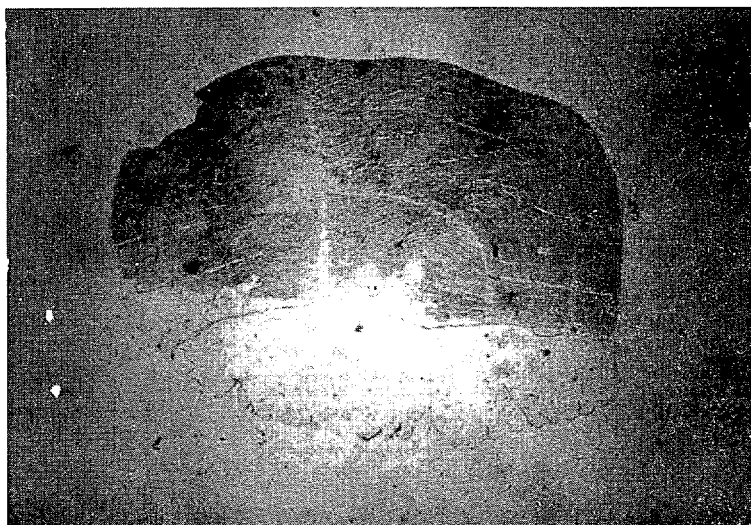
28. Ice conditions in the Chukchi Sea in July not only preclude entry of the *M V Royal Atlantic* into Kotzebue Sound but also severely hindered coastal test fishing efforts.



29. A common sampling problem encountered in the early spring. Drifting pan ice often reduced the soak time of many gillnet sets.



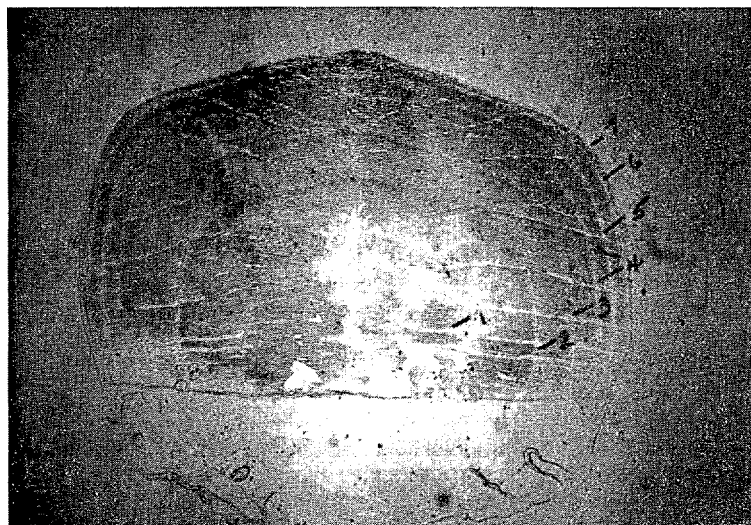
30, 31, 32. A typical set and catch with the 61 meter (3 mm mesh) beach seine near Shaktoolik, 1976.



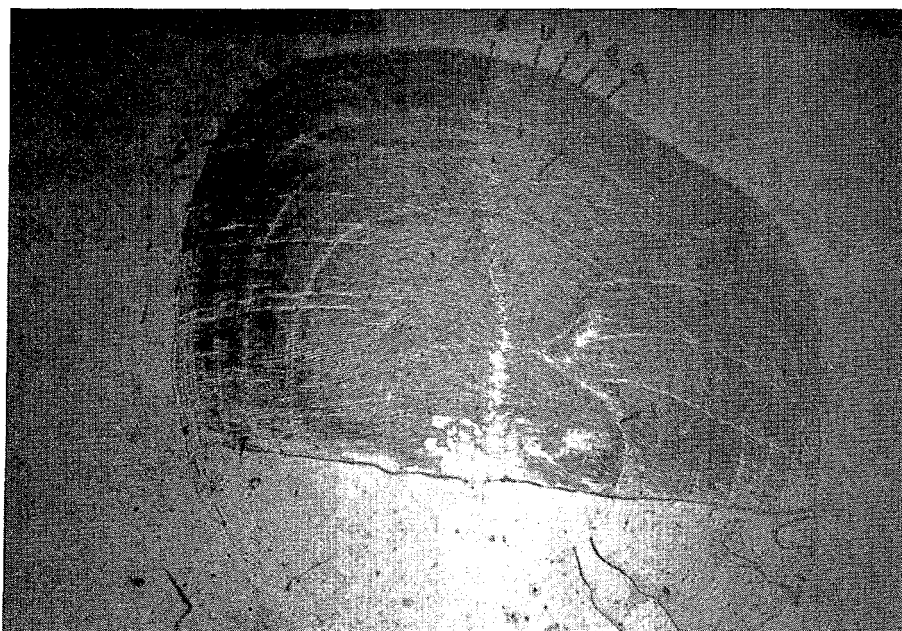
33. A three-year-old herring as indicated by the annual rings on scale. This is generally the earliest that sexual maturity occurs in eastern Bering Sea herring.



34. A five-year-old herring. The 1972 brood year was the dominant spawning age class of herring along most of western Alaska in 1977.



35. A seven-year-old herring; sampled in Grantley Harbor, July 10, 1977.



36. A nine-year-old herring;
sampled in Port Clarence,
July 10, 1977.



37. A fifteen-year-old herring; sampled in Grantley Harbor, July 1, 1977. This was
the oldest ageable herring captured in 1977.



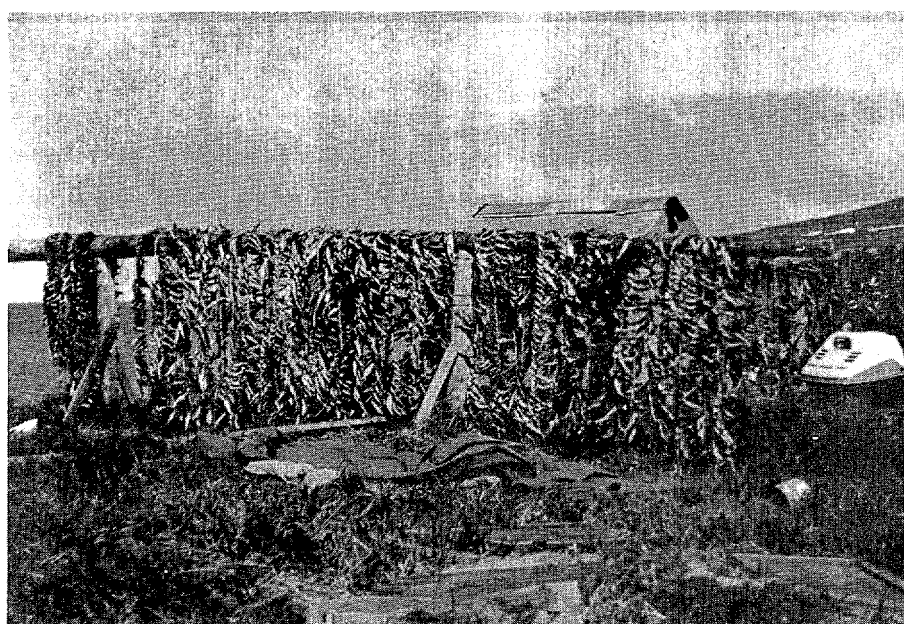
38. Sampling beach seine catches became more tedious in the fall months as storms created heavy debris (algae & seaweed) problems in coastal waters.



39. Beach seine sampling in Port Clarence in September, 1977.



40. The most abundant fish captured in Norton Sound in 1976 and 1977 was Pacific sand lance. Young sand lance were tedious to sample; shown here in 3 mm mesh beach seine, Golovin Bay.



41. Herring are often woven into grass strings and allowed to sun-dry for several days. Herring are an important subsistence food item to many coastal residents of western Alaska.



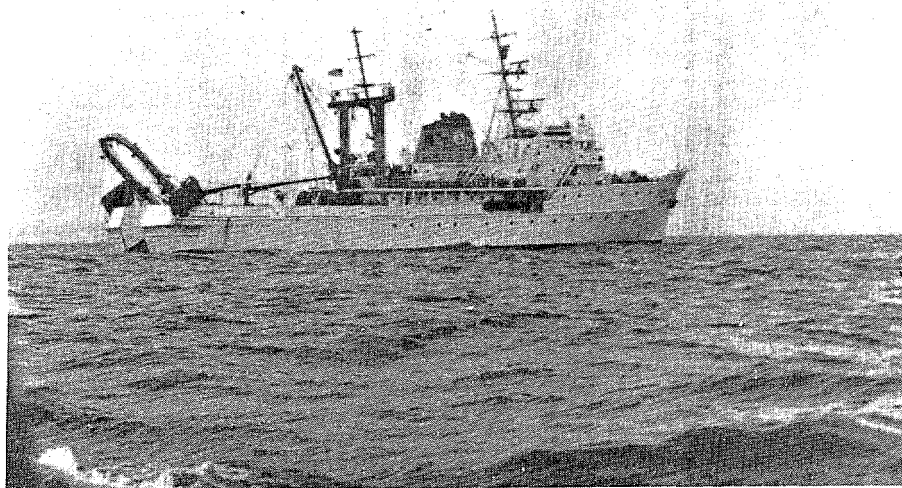
42. An OCS ground crew hand sampling spawning capelin near the village of Tununak, 1976. This is typical of capelin spawning habitats; fine sand and gravel beaches.



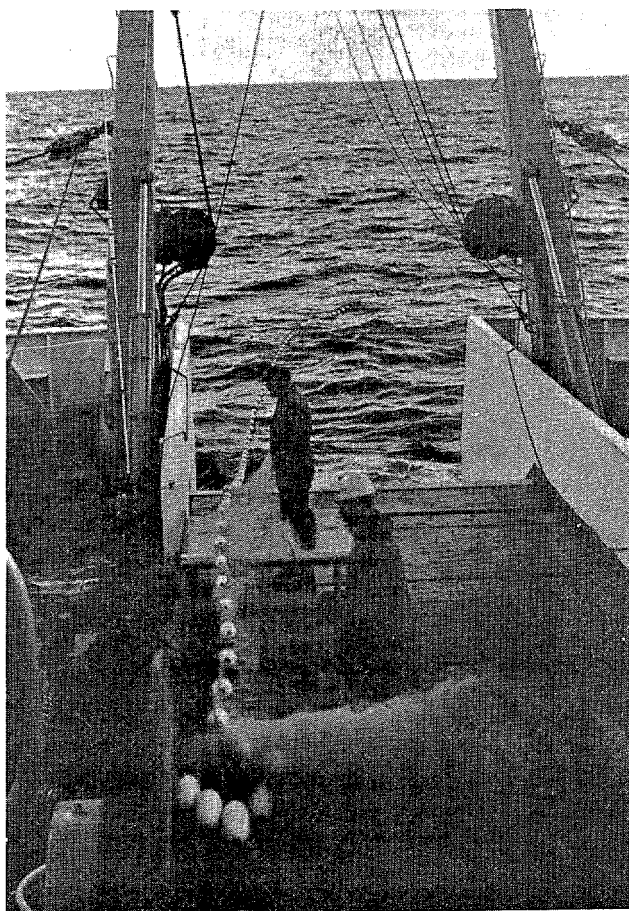
43. Spawning capelin at Nelson Island, June 24, 1976. No white water characteristic of herring spawning was observed. Note enlarged anal fin of spawning males.



44. Capelin carcasses left stranded on the beach after the spawning act.



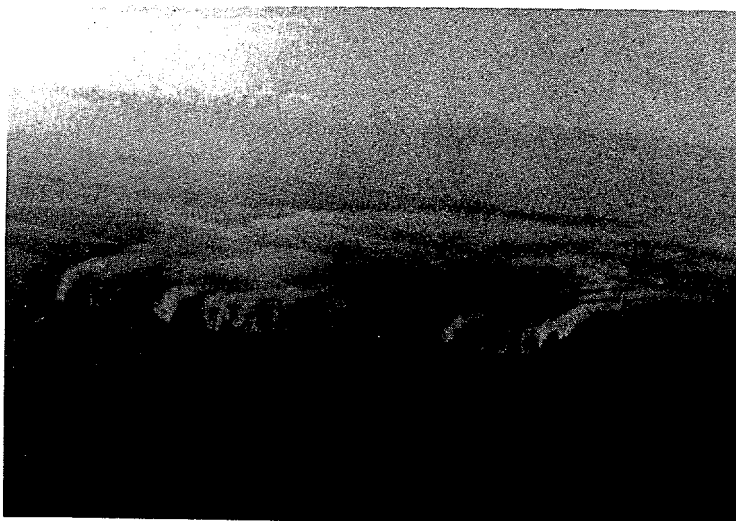
45. The NOAA ship *Miller Freeman* investigated fishery resources in the offshore waters of Norton Sound and Kotzebue Sound in September and October, 1977.



46. Retrieving variable mesh long-line gillnets aboard the NOAA Ship *Miller Freeman*, September 1976.



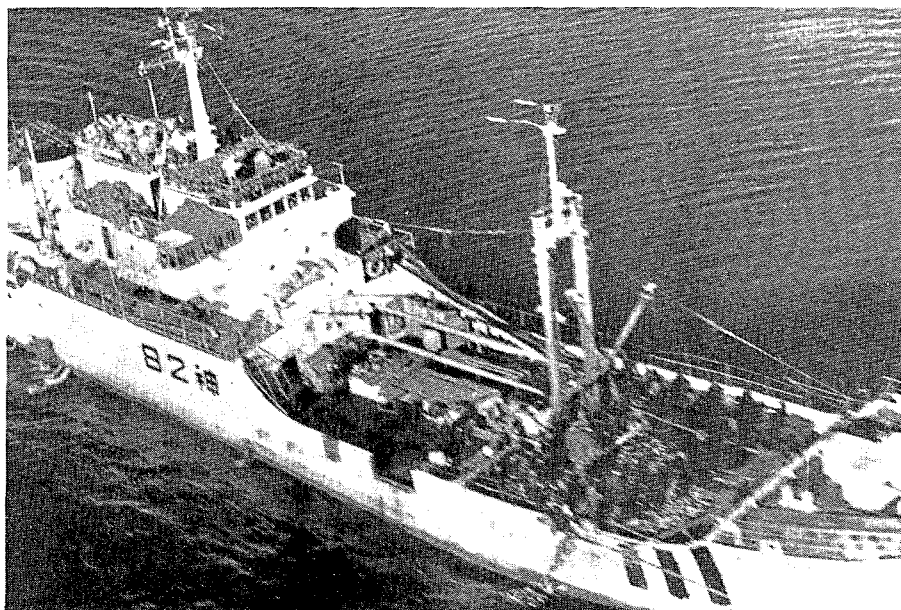
47. Freeze up of Grantley Harbor occurred overnight in 1977. Photograph shows village of Teller at the outlet of Grantley Harbor on October 16, 1977.



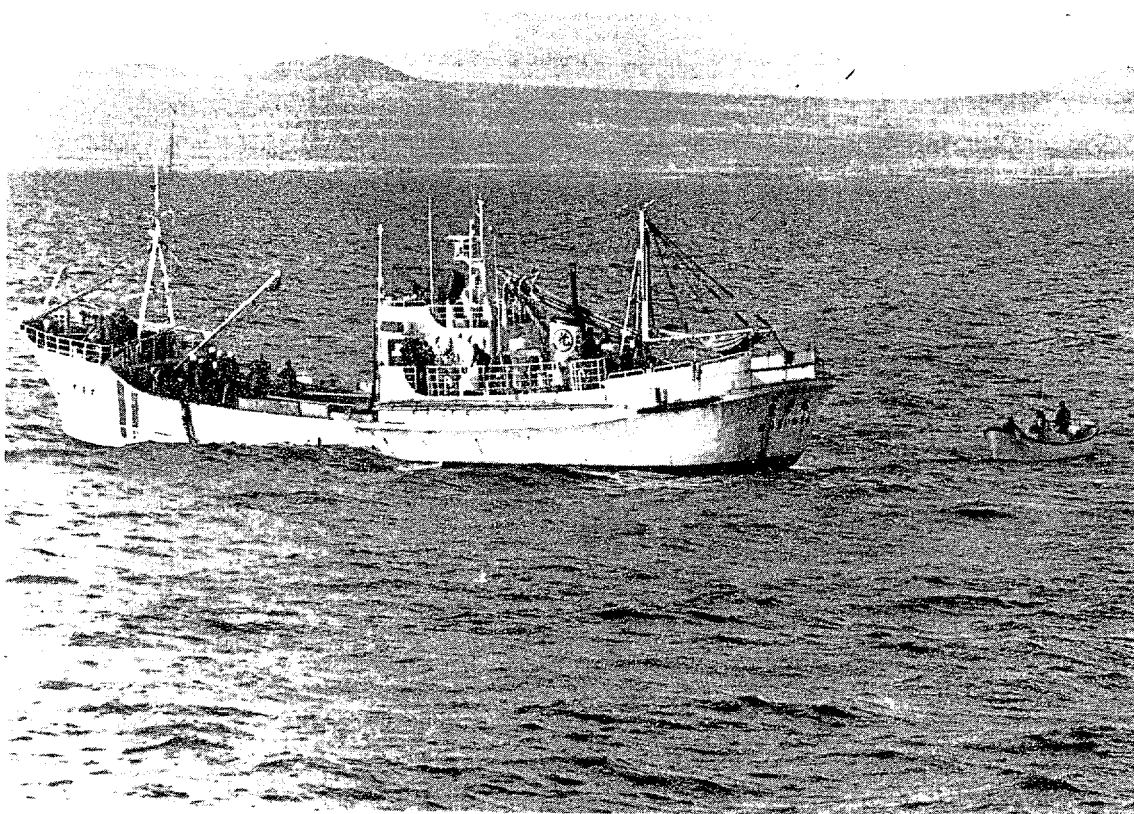
48. Smoke from one of many tundra fires on the Seward Peninsula which hindered aerial surveys in the fall of 1977.



49. Turbid water conditions near Cape Wooley generated by fall storms which hampered aerial surveys.



50.51. Japanese herring gillnetters in Norton Sound, June, 1968. The first foreign commercial effort for herring in Norton Sound occurred in 1968. Approximately 120 metric tons of herring were harvested by three Japanese vessels positioned about 20 km offshore in the area between St. Michael and Golovin Bay.



52. One of two Japanese gillnetters which were apprehended on June 7, 1969, for fishing within the U. S. contiguous zone in the vicinity of St. Michael. The two vessels had a total of 22 tons of herring aboard consisting of mostly spawned out males. The Japanese operated in Norton Sound in 1969 with a fleet of about 40 ships; peak foreign herring catches were experienced that year which amounted to nearly 1.300 metric tons.

RESEARCH UNIT 64

The following were submitted as the final report for this research unit:

Macy, Paul T., Janet M. Wall, Nickolas D. Lampsakis, and James E. Mason (1978) . Resources of Non-Salmonid Pelagic Fishes of the Gulf of Alaska and Eastern Bering Sea, Northwest and Alaska Fisheries Center, NMFS, Seattle, Washington 98112.

Part 1 - Introduction; General Fish Resources and Fisheries;
Review of Literature on Non-Salmonid Pelagic Fish Resources,
pp. 1-356.

Part 2 - Historical Data Record of Non-Salmonid Pelagic Fishes,
pp. 357-714.

Part 3 - Data Appendices, 329 pp.

RESEARCH UNIT 68

The following was submitted as part of the final report:

Mercer, Roger W., Bruce D. Krogman, Ronald M. Sonntag (1978).
"Marine Mammal Data Documentation for the Platforms of Opportunity
Project and Outer Continental Shelf Environmental Assessment
Program", Northwest and Alaska Fisheries Center, NMFS, Seattle,
Washington 98112, processed Report, 92 pp.

INTERTIDAL BIOTA **AND SUBTIDAL KELP COMMUNITIES**
OF THE KODIAK ISLAND AREA

by

Steven T. Zimmerman, Joyce L. Hanson, Jeffrey T. Fujioka,
Natasha I. Calvin, Jessica A. Gharrett, John S. MacKinnon^{*}

Research Unit 78

^{*}Northwest and Alaska Fisheries Center Auke Bay Laboratory
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PREFACE

In 1974 the National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce, contracted with the Bureau of Land Management (BLM), U.S. Department of the Interior, to provide an environmental assessment of the northeastern Gulf of Alaska. This assessment was designed to provide a measure of the environmental risk associated with oil and gas exploration and development in the offshore areas of the region. NOAA, through its Environmental Research Laboratories, established the Outer Continental Shelf Environmental Assessment Program (OCSEAP). OCSEAP contracted with universities and state and federal government agencies to provide BLM with the data for preparation of an environmental impact statement for the northeastern Gulf of Alaska. The Northwest and Alaska Fisheries Center Auke Bay Laboratory, National Marine Fisheries Service (NMFS), NOAA, was contracted to assess the distribution of intertidal (littoral) communities in the eastern Gulf of Alaska in 1974 and expanded these studies to include the western Gulf of Alaska and eastern Bering Sea in 1975.

This report is an analysis of intertidal data from sites in the Kodiak Island area of the western Gulf of Alaska. The Kodiak Island area includes the Trinity Islands; Kodiak, Sitkalidak, Afognak, Shuyak, and closely-associated smaller islands; Chirikof Island to the southwest of the Trinity Islands; the Barren Islands at the mouth of Cook Inlet; and the Alaska Peninsula across Shelikof Strait from Kodiak Island.

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INTRODUCTION

The distribution (Harriman Alaska Expedition of 1899, Rigg 1915, Bousefield and McAllister 1962, Dreuhl 1970, Nickerson 1975) and composition (Nybakken 1969, Weinmann 1969, Hubbard 1971, Lebednik, Weinmann, and Norris 1971, O'Clair and Chew 1971, Calvin 1977, Rosenthal and Lees 1977) of intertidal species and assemblages in the Gulf of Alaska are relatively unstudied. Many of the available data have been reviewed and summarized by Feder and Mueller (1972) and the Arctic Environmental Information and Data Center (1974).

Intertidal communities in the Gulf of Alaska, and more specifically in the Kodiak Island area, have many features in common with those in other subarctic and northern temperate regions (Lewis 1964, Stephenson and Stephenson 1972, Kozloff 1973). For instance, Lewis' (1964) description of the Rhodophyceae zone of northern Scotland and Ireland almost perfectly fits the situation we found at similar latitudes in the Kodiak Island area. Many of the species which Scagel (1971) and Kozloff (1973) described as being common in the Puget Sound and British Columbia regions are also common in Alaska. The known ranges of other intertidal species are being extended into the Gulf of Alaska as previously unstudied areas are surveyed (Lindstrom and Calvin 1976).

The overall objective of this study has been to generally describe the distribution of littoral habitats and their associated biota by a combination of qualitative and quantitative observations. Because of the immense area covered and limited time, our research has necessarily been extensive rather than intensive. The results generally reflect a "survey" approach rather than the more prediction-oriented baseline or monitoring approaches which are often used to study areas of potential impact. As these littoral areas are more clearly delineated, our research will be oriented toward monitoring changes in specific areas.

This report summarizes the results of our work in the Kodiak Island area and makes the information available before leasing decisions concerning that area are made. We have attempted to determine (1) the distribution and percent occurrence of each type of major intertidal habitat and (2) the assemblages of plants and animals that occur in these habitats.

The distribution of habitat types was determined by an observer in an airplane who surveyed the coastline from an altitude of 50-100 m (150-300 ft) (Sears and Zimmerman 1977). Concurrently, research teams based on the NOAA Vessel SURVEYOR* or working with Alaska Department of Fish and Game (ADF&G) on the OCSEAP Razor Clam Study† landed at several sites to quantitatively assess the types of organisms occurring in different intertidal habitats. Finally, in July 1976, an "overview" trip was made by helicopter to visit a large number of sites which were qualitatively assessed to describe apparent major differences between habitat types. The survey lasted over a year, beginning in May 1975 and ending in August 1976. Approximately 40 sites were visited (Figure 1) and over half were sampled quantitatively.

* A total of three SURVEYOR trips were made in the Kodiak area.

† ADF&G biologists concentrated on species of commercial molluscs. The NMFS biologists were primarily responsible for collecting and identifying associated organisms.

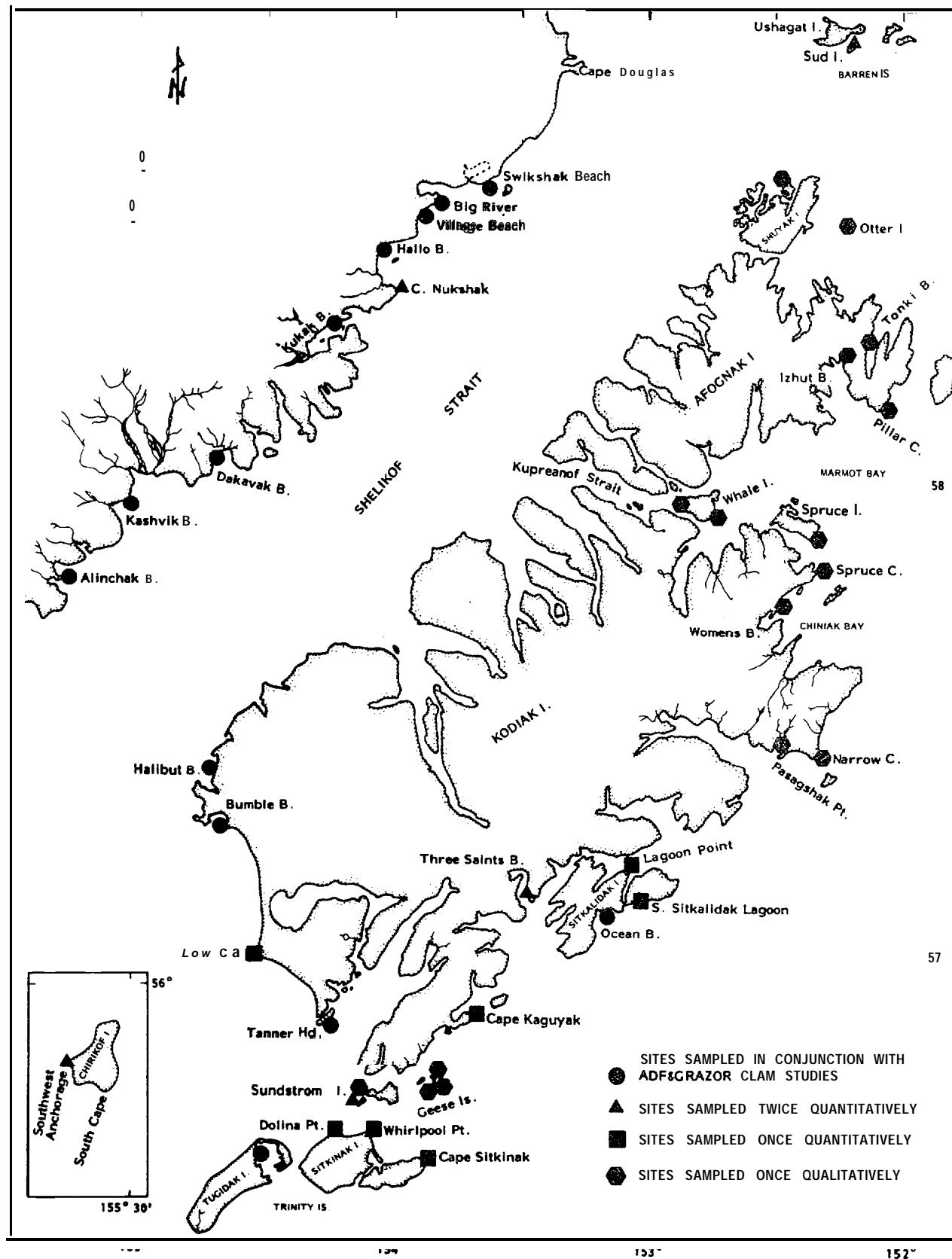


Figure 1. Intertidal sites sampled in the Kodiak area, 1975-76,

DESCRIPTION OF THE KODIAK ISLAND AREA

The area studied extends from Chirikof Island (55° 45'N, 155° 45'W) in the south to the Barren Islands (58° 55'N, 152° 01'W) in the north (Figure 1) and includes approximately 13,000 km² (5,000 mi²; Capps 1937) of land. The largest land mass is Kodiak Island. Many long and narrow bays penetrate the islands, 'resulting in an irregular coastline almost 4,000 km (2,500 mi) long (Table 1). In the northern areas the slope of the beaches is generally quite steep. To the south the coastal shelf broadens and beaches are correspondingly lower in gradient (Capps 1937).

The tidal range is great. The mean diurnal range, or average difference between mean lower low water (MLLW) and mean higher high water (MHHW), averages about 3.4 m (11 ft) and exceeds 4.3 m (14 ft) in some areas. During spring tides the extreme difference may be as great as 6.7 m (22.5 ft) in Kupreanof Strait. Tidal ranges are slightly greater in the northern areas than in the southern.

Table 1. Number of kilometers and percent of major substrate types in the Kodiak Island area.

Substrate	Kodiak and Afognak islands	Barren Islands	Trinity Islands	Chirikof Island	Total km	Percent
Bedrock	1,775	90.0	15.3	26.5	1,907	48.1
Boulder	479	2.4	5.6	3.2	490	12.4
Gravel	1,191	2.4	55.0	0	1,248	31.5
Sand	127	6.4	151.0	23.3	308	7.8
Mud	9	<u>0</u>	<u>0</u>	<u>0</u>	9	<u>0.2</u>
Total km	3,581	101.2	226.9	53.0	3,962	100.0

AERIAL OBSERVATION METHODS

Aerial observations (Sears and Zimmerman 1977) provided information on beach slope, beach composition (bedrock, boulder, gravel, sand, mud), and density of biological cover. All flights were made in May 1976 during the period from 2 h before to 2 h after low tides ranging from -2.6 to +1.0 ft. Only beach types which extended for 50 to 100 m or more were noted on survey charts. Other biological data were also noted whenever possible, including the locations of sea bird rookeries, sea mammal haul-out areas, swimming sea mammals, dead sea mammals, eagles, land animals on beaches, large concentrations of surf grass, and offshore kelp beds.

INTERTIDAL FIELD METHODS

In May 1975 an aerial reconnaissance of the Kodiak Island area was made to choose intertidal sampling sites. Two weeks later the first quantitative sampling began at seven sites in the western Gulf of Alaska. Four of these (Sud Island, Three Saints Bay, Sundstrom Island, Chirikof Island) were all in close proximity to the Kodiak lease area and are extensively discussed in this report.

The NOAA vessel SURVEYOR (Figure 2) transported field parties to the previously chosen general areas. A ship-based helicopter (Figure 3) was then used to survey specific areas and to transport field parties to the sites to be sampled. A second cruise to the same sites was made in August 1975.

In May 1976 a third SURVEYOR cruise was made. Data from the aerial survey were used to choose seven new sites for quantitative sampling (Cape Kaguyak, Cape Sitkinak, Lagoon Point, Dolina Point, Low Cape, South Sitkalidak Lagoon, and Whirlpool Point). An additional area on Sundstrom Island was qualitatively examined by placing four field parties ashore at different sites to note major differences across large areas.

In July 1976 a final trip was made to observe general distribution of dominant littoral species in areas not visited previously. Approximately 15 sites in nine general areas were qualitatively examined by two observers noting the distribution of species with respect to exposure and substratum type and slope.

Rocky Beaches Large Boulder and Bedrock Beaches

At each of the sites with large boulder or bedrock substrates, one to three transect lines (Figure 4) were extended across the beach from the highest area of tidal influence to the water's edge at low tide. The number of lines used at each site was determined by the slope and biological homogeneity of the beach: on a low-gradient beach often only one long line (75-200 m) was sampled, whereas on a steep beach as many as three short lines (15-50 m) were sampled.

Sampling frames (1/16 m²) were laid at regular intervals along the line. The area under each frame was photographed, the percent of cover contributed by the dominant organisms was enumerated when time permitted, and then the biota were scraped from the rocks (Figure 5) and preserved in 10% formal in. The elevation of each sample was determined with a transit and stadia rod using standard survey procedures (Figure 6). Elevations were measured with respect to predicted low tide levels, and the heights of permanent bench marks were established for some beaches.

A second sampling method developed by Dr. Richard T. Myren, Auke Bay Laboratory, was used to study the faces of large boulders or hummocks. This method, hereafter referred to as the "arrow" method, involved sketching a facsimile of the area to be sampled and the biotic zonation on a sheet of Mylar* plastic. Numbered, homogeneously-arrayed dots were then placed on

* Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

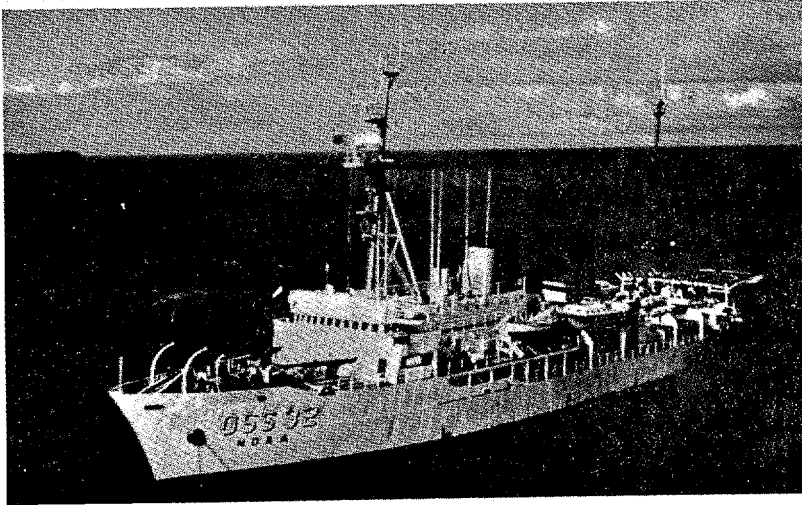


Figure 2. The NOAA vessel SURVEYOR was used to transport field parties to remote locations during three of the sampling periods.

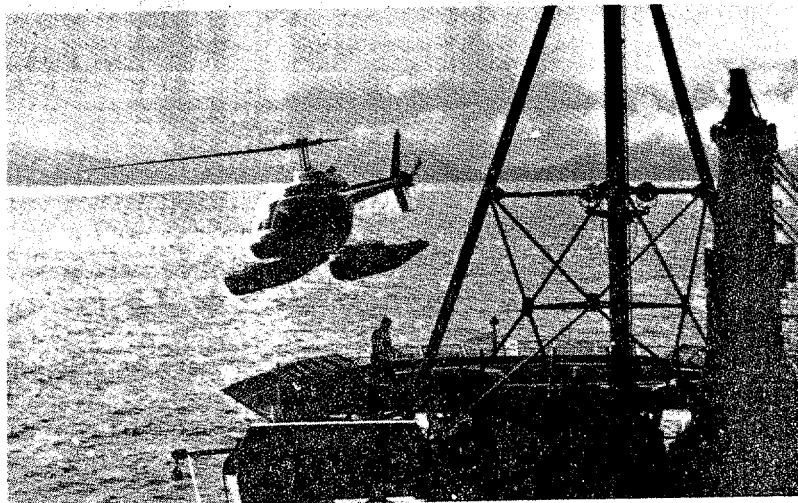


Figure 3. A NOAA helicopter was often used to transport field parties ashore.



Figure 4. Sampling a $1/16 \text{ m}^2$ quadrat along a transect line on a bedrock substrate.

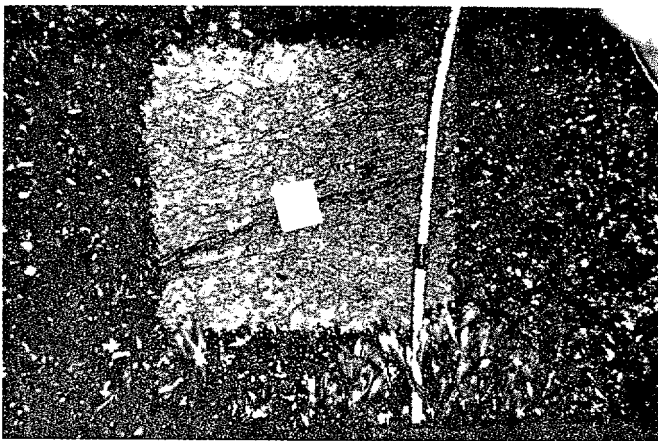
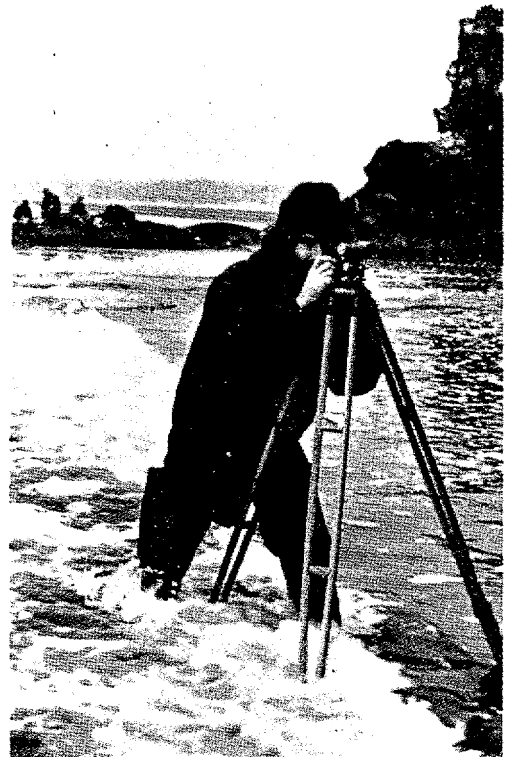


Figure 5. View of quadrat after collecting biota.

Figure 6. Measuring tidal elevations.



the sketch. A random-number table was used to choose dots (usually between 10-30 in number), and numbered arrows and 1/16 m² quadrat frames were then placed at the corresponding locations on the rock faces (Figure 7). Photography (Figure 8), determination of tidal heights of quadrats, and enumeration of cover followed, and quantitative collections (1/16 m²) were taken in other areas with similar biota. The rock face itself was left undisturbed as a study site for future comparison.

Small Boulder Beaches

Areas composed almost entirely of small (<2 ft²) boulders were generally uncommon. They were sampled at two sites using methods similar to the transect line sampling described in the preceding section. Where cover was sparse and patchy, 1-m² instead of 1/16-m² frames were used.

Gravelly and Sandy Beaches

A 1-liter (10 cm on a side) corer was initially used to sample gravelly and sandy beaches in the Kodiak island area. It was immediately apparent from the paucity of visible organisms, however, that larger volumes should be sampled. Working in conjunction with the AD F&G Razor Clam Study, we were able to use a method that sampled much larger volumes of beach material. In this method 21- by 3-m plots were laid out with the long axis parallel to the beach. Positions differed by 1-ft tidal intervals (-2, -1, 0, +1 ft, etc.), and five to eight such plots were sampled on each of eight beaches. Three 1/3-m² subplots were randomly located within each plot and excavated to a depth of 0.3 m (1 ft). This large volume (101.6 liters per subplot) was then washed through a fiberglass screen with 1.59-mm openings (Figure 9) which was mounted on a cart. The cart (Figure 10) was equipped with a generator, pump, and long intake hose, which making it possible" to wash large volumes of sediment in the field.

Muddy Beaches

Muddy beaches are relatively uncommon in the Kodiak Island area (Table 1). At South Sitkalidak Lagoon quantitative samples were collected along a transect line using a 1-liter (10 cm on a side) coring device (Figures 11 and 12). The corer was often used twice vertically, once to collect biota from the 1- to 10-cm depths and a second time to collect from the 10- to 20-cm levels. Replicate samples were also collected at each position along the line. In addition, qualitative sampling was done in South Sitkalidak Lagoon and at McDonald Slough in Izhut Bay on Afognak Island. These collections were made to determine species present after a general survey of the areas had located the major biological communities.

SORTING METHODS

All samples of sand, mud, and gravel were processed at the NMFS laboratory in Kodiak. After removing a small amount of sediment for analysis of particle size, each sample was examined for organisms, and all organisms were identified, counted, and weighed wet. Species were verified using the museum collection at the University of Alaska Marine Sorting Center in Fairbanks.



Figure 7. An example of a vertical rock face being sampled using the arrow method for randomization of samples.



Figure 8. Measuring tidal elevations and photographing quadrats on a vertical rock face.

Figure 9. View of washing
box for gravel and sand
samples.

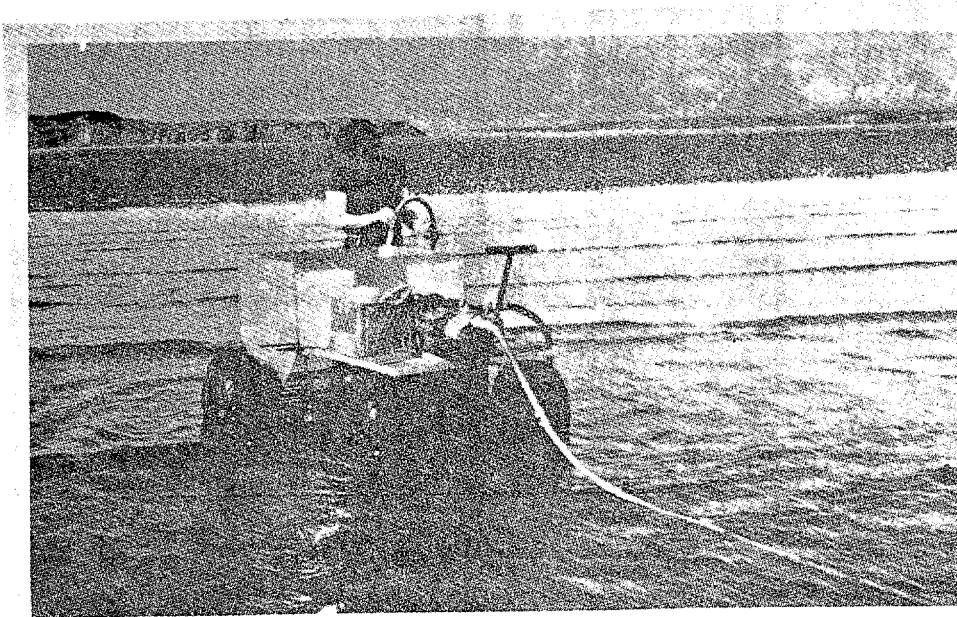
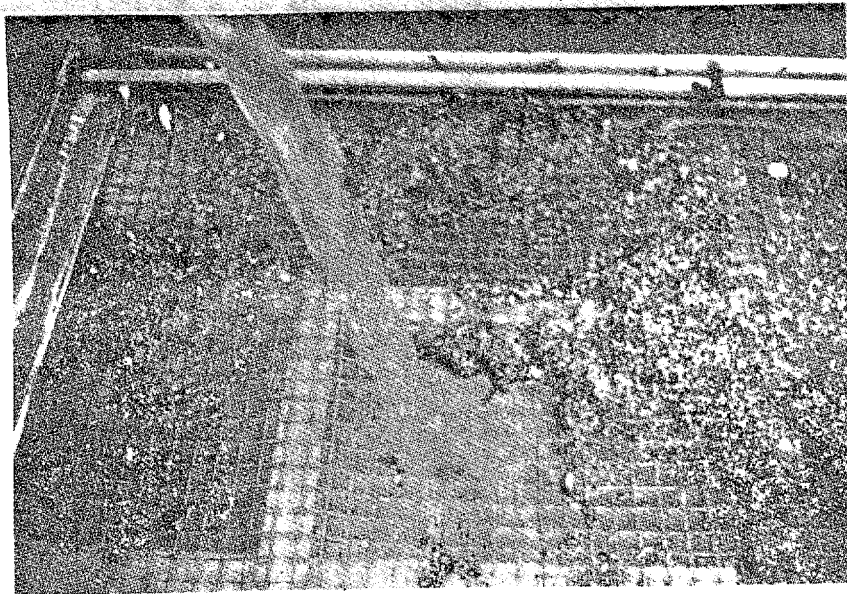
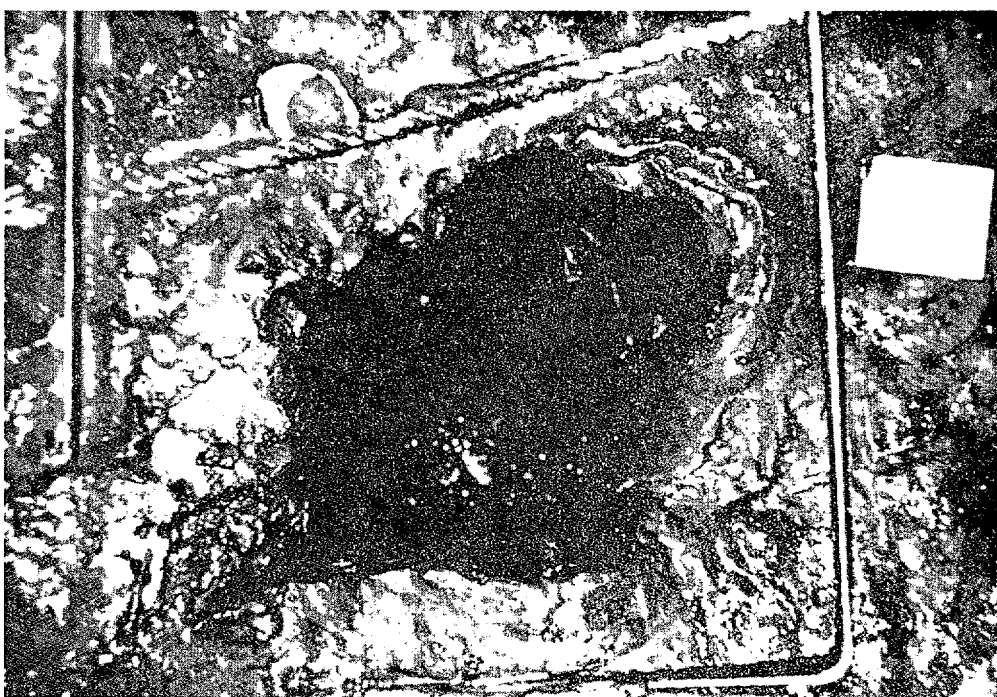


Figure 10. View of **cart** used to sieve gravel
and sand samples in the field.



Figure 11. Sampling a muddy beach along a transect line.

Figure 12. View of quadrat after removing a 1-liter quantitative core of mud.



Samples from rocky beaches were sorted in two groups. All 1975 samples were sorted by University of Alaska Marine Sorting Center personnel and all 1976 samples were sorted **by Auke Bay Laboratory biologists**. Some differences between results from the two sorting groups occurred due to differing levels of expertise on specialized groups of organisms. **The Marine Sorting Center, for instance, often carried annelid identifications to species while Auke Bay Laboratory biologists made identifications only to class or order.** Collections of identified organisms were exchanged, however, and there were no major differences in identification of the common species.

Sorting by both groups was done in the following manner. Organisms were sorted, identified, counted, and weighed. Wet weights were recorded by Auke Bay Laboratory scientists, and both wet and dry weights were recorded by the Marine Sorting Center. Fertile and sterile plants of the two most common algae, Fucus and Alaria, were noted, and weights for the different stages were recorded separately. Data on mussels and limpets were divided into two or three categories based on animal size. Finally, after the dominant organisms had been removed, leaving a residual mass of small fragments, estimates of the remaining individuals were determined by subsampling.

AERIAL SURVEY

The coastline of the Kodiak Island area is approximately 3,900 km (2,500 mi) long (Table 1). Over half the coastline is composed of bedrock or large boulder beaches and the exposed coastline on the Gulf of Alaska side is almost entirely rock. Gravelly and sandy beaches make up much of the remaining coastline. Muddy beaches account for less than 1% of the coastline.

Using the aerial observations of biological cover, we determined which intertidal areas had been classified as having "heavy" cover on more than half of the rocky outer coastline (Figure 13)*. The areas used in this analysis are the same as those used to depict the Kodiak coastline in the intertidal atlas (Sears and Zimmerman 1977). Heavy cover occurred in the area of the Trinity and Geese islands, Kodiak Island south of Kupreanof Strait, and the northeastern side of Kodiak Island including Marmot Bay.

We also calculated the ratio between the sightings of offshore floating kelp beds and the miles of coastline (for instance, if five kelp beds were noted along 50 mi of beach the ratio would be 0.10). The data (Figure 14) indicate the greatest number of kelp beds are off the southeastern portion of Kodiak Island. In general, this part of the island has a wider shelf (Capps 1934) than the quite steep northern portion, and the more extensive kelp beds could be due to the wider shelf providing more substrate for attachment.

INTERTIDAL SURVEY-- ROCKY BEACHES Physical Parameters

The success of each species on rocky intertidal beaches is affected by many factors, such as differences in type and slope of substrate; occurrence of

* Because heavy biological cover is sometimes not found in the upper parts of bays due to ice scouring, low salinity, siltation, and reduced currents, the rocky coastlines used for these calculations were limited to areas along the open coast or mouths of bays.

Figure 13. **Distribution** of heavy intertidal cover in the Kodiak area. Shaded areas represent coastline for which 50% or more of the intertidal beaches are heavily covered with **biota**.

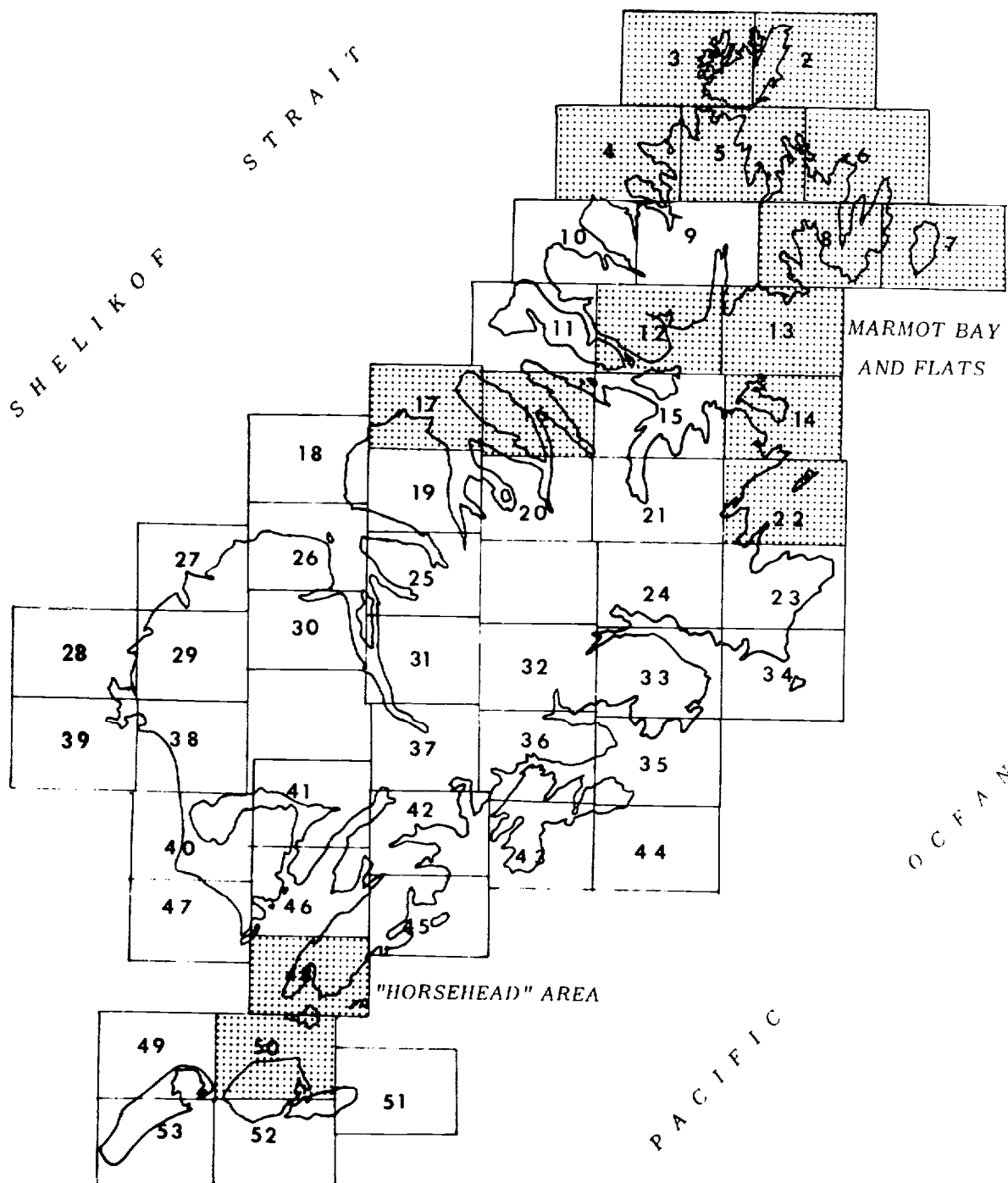
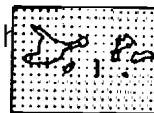
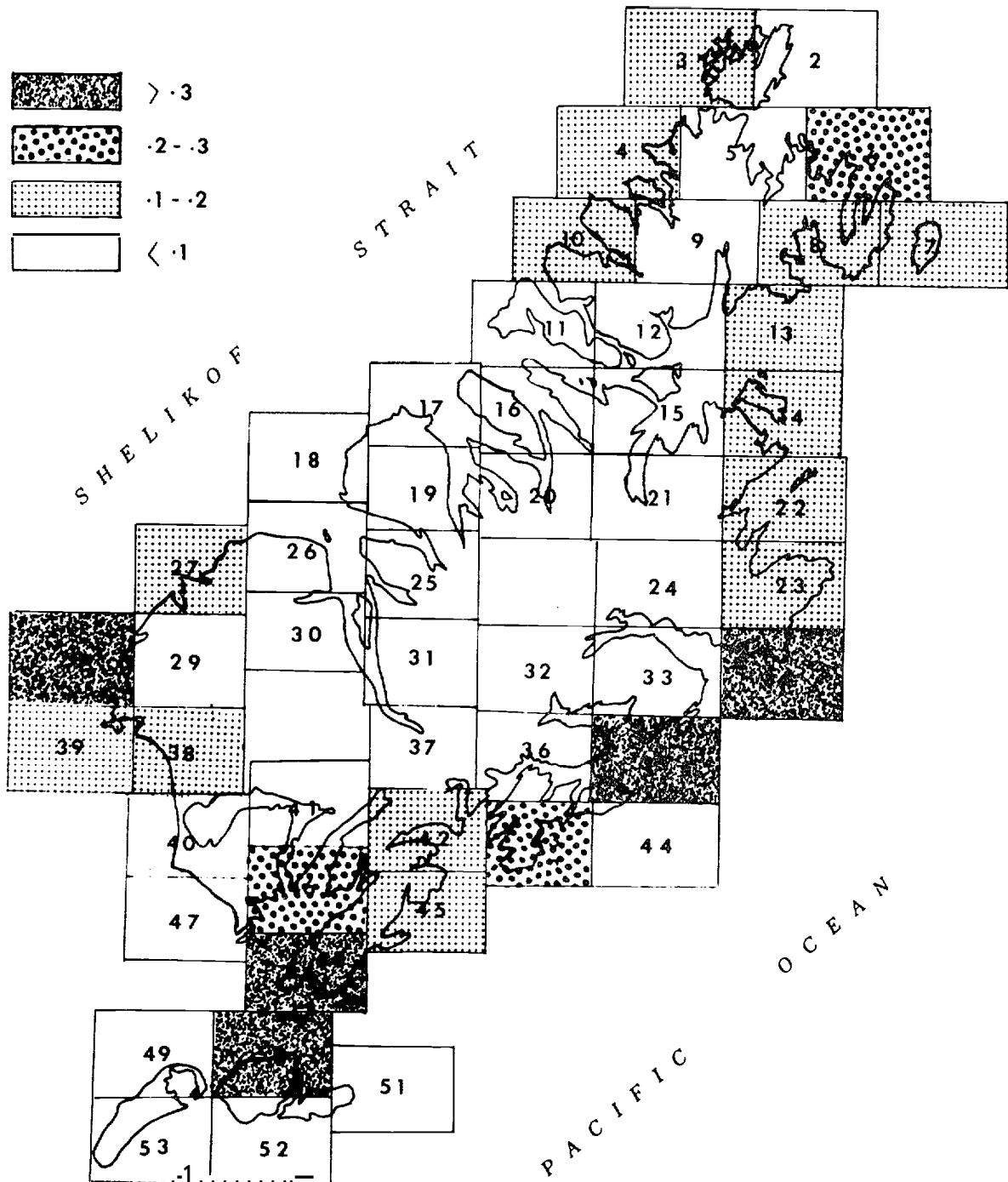
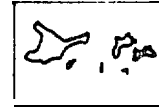


Figure 14. Distribution of beds of floating kelp in the Kodiak area. Ratio = $\frac{\text{number of kelp bed sightings}}{\text{number of miles of coastline}}$



crevices; amount of standing water; exposure to waves, winds, sand, and ice; and occurrence of competitors and predators. Our sites were only visited once or twice, and many of the major factors cannot be measured without several seasons of research at each site. We had hoped, however, to be able to account for part of the variability by correlating the occurrences of major biotic assemblages with two of the most obvious physical factors, substrate type and degree of exposure.

Substrate

We initially tried to follow the format developed in the aerial reconnaissance when designating habitat type by substrate (i.e. , bedrock, boulder, gravel, sand, mud). Examination of several sites, however, indicated that some important habitat types are not accounted for by this system. The major categories of rocky habitat are described below.

Because of the low gradient of flat bedrock beaches, much of their area is usually covered by standing water after the tide has receded. This allows organisms from lower intertidal or subtidal zones to intermingle with species which normally occur higher on the beach (O'Clair and Chew 1971). In this situation, distance from the low water line may be more important than vertical elevation in determining zonation. Another feature of flat bedrock beaches is the lack of hummocks, crevices, and other vertical relief features which provide localized protection from surf.

Steep bedrock or boulder beaches have overhangs, crevices, various exposures to wind and waves, shading, and many other features which provide diverse microhabitats and thus some of the most biologically complex areas we encountered.

Beaches composed of small boulders at exposed locations (e.g. , Low Cape, Dolina Point) have very little attached biota, probably as a result of lack of relief combined with battering of boulders during storms.

Exposure

Exposed, unprotected beaches have fewer animal species and lower biomass than do more protected areas (Ricketts and Calvin 1968). Unfortunately, our brief one- or two-day reconnaissance at each site made it impossible to evaluate the effects of wind, storm surf, the presence of offshore bars, kelp beds, or other more subtle features which modify the amount of exposure of the biota. Therefore we chose simple descriptors, i.e. , exposed, partly protected, and protected. We generally based the decision on the apparent amount of protection provided by adjacent land masses.

Exposed locations are those which have either little or no protection from physical oceanic forces. Partly protected sites lie inside bays or have protective offshore islands, reefs, or other topographic features. Protected sites usually lie well within bays and are shielded **in several directions from oceanic forces.**

We tried several statistical methods to determine and analyze the relationship between substrate, exposure, and biota. Before the methods and results are discussed, however, a general description of each site and its dominant biota is presented.

Quantitative Surveys: Description of Sites and Biota

Two types of surveys were made: "qualitative," which were quick surveys by two observers, and "quantitative," which extended over one or two entire low tide cycles and were done by a team of six or more biologists.

On quantitative surveys, organisms were collected from measured quadrats or cores as described in "Intertidal Field Methods." Summary descriptions of the sites we sampled quantitatively are given in Table 2. The organisms found in the quantitative collections at each site are shown in Tables 3-5. Each description of a quantitative survey site in this section of the report is accompanied by a map of the sampling location, photographs of the area, a graph of horizontal and vertical distributions of algae and invertebrates, and a graph showing the density of selected intertidal organisms.

Chirikof Island

Chirikof Island lies in the Gulf of Alaska about 50 km (80 mi) east of the Alaska Peninsula and about 50 km southwest of Kodiak Island (Figure 15). It is exposed to severe wave impact, somewhat moderated by offshore reefs. The area we sampled at West Point is characterized by a long, low reef system, most of it lying below mean low water (MLW) (Figures 16 and 17). The beach above the tideline is also low gradient and is entirely sand. The upper side of the sandy beach is covered by a jumble of large weathered logs stranded by storm surf.

We sampled part of the large reef area in May and August 1975 using (1) the arrow method on a high-relief area with elevations ranging from 3.6, ft to -1.4 ft (Figure 18), and (2) the transect line method on an area near the arrow site but lying entirely below MLW. The arrow site was bedrock and thus more stable than the transect line site which had small cobbles and sand over bedrock. The stable bedrock and greater range of elevation at the arrow site provided additional habitats in the form of crevices and overhangs, giving some protection for motile invertebrates; these habitats were not found along the low-lying transect line. Because of its low gradient, the transect line area had many small tidepools and areas of standing water, even at low tide.

The arrow site was an area of the bedrock reef with an eroded surface perpendicular to and facing the ocean. The arrows were placed on the top, side, and overhangs of this face in an area about 10 m long. Much of the area had a heavy cover of the large barnacle Balanus cariosus which in turn was covered with sponges, coral line algae, small-bladed red algae such as Iridaea cornicopiae, and large fertile Alaria sp. The Alaria were uneroded with large, entire blades. Laminaria longipes was also seen in the arrow site. We also saw Henricia leviuscula, Katharina tunicata, Collisella pelta, and large littorine snails.

The beach at the low end of the transect line was a bedrock substrate somewhat similar to the arrow site area and was covered with sponges and fertile, uneroded Alaria, Rhodomelalarix, and Iridaea cornucopia (Figures 19-22). Higher on the line, in an area of cobbles, large pebbles, and standing water, we observed a large amount of Odonthalia floccosa and Rhodomelalarix in low areas, with Alaria sp. and Fucus distichus growing on the boulders. In this area some of the Alaria had eroded blades with only

Table 2. --Description of intertidal sites and types of samples taken in the Kodiak Island area, 1975-76: sites sampled quantitatively.

Location	Exposure	Substrate	Dates Sampled	Elevation Range Sampled (ft)	Sampling Method*	Sample Size	Number of Transects
Chirikof Is.	Exposed	Flat bedrock	5-27-75 8-10-75	+3.6 to -1.4	A Q	1/16 m ²	2
Sitkinak Is.	Exposed	Flat bedrock	5-13-76	+3.0 to -0.5	Q V	1/16 m ²	1
Sud Is.	Exposed	Hummocky bedrock or large boulder	5-23-75 8-8-75	+10.9 to -2.9	A Q	1/16 m ²	3
Cape Kaguyak	Partly protected	Hummocky bedrock or large boulder	5-12-76	+9.8 to -1.3	Q V	1/16 m ²	2
Three Saints Bay	Partly protected	Hummocky bedrock or large boulder	5-28-75 5-29-75 8-7-75	+9.0 to -0.8	A Q	1/16 m ²	2
Lagoon Point	Partly protected	Hummocky bedrock or large boulder, sand	5-15-76 5-16-76	+8.1 to -3.2	Q V C	1/16 m ² 1 liter	4
Low Cape	Exposed	Small boulder	5-17-76	+7.1 to -1.0	QV	1 m ²	1
Dolina Point	Exposed	Small boulder	5-14-76	+4.2 to +1.5	Q V	1 m ² 1/16 m ²	1

Table 2. --Continued.

Location	Exposure	Substrate	Dates Sampled	Elevation Range Sampled (ft)	Sampling Method*	Sample Size	Number of Transects
So. Sitkalidak Lagoon	Protected	Mud	5-19-76	+3.3 to +0.6	c	1 liter	1
Tanner Head	--	Small rock, sand	5-15-76	+6.0 to -1.0	c	304.8 1	1
Halibut Báy	--	Small rock, sand	5-30-76	+8.0 to -1.0	c	304.8 1	1
Swikshak Beach	--	Small rock, sand	6- 9-76	+4.0 to -1.0	c	304.8 1	1
Village Beach	--	Small rock, sand	6-1"1-76	-1.0 to -4.0	c	304,8 1	1
Big River Beach	--	Small rock, sand	6-12-76	+3.0 to -2.0	c	304.8 1	1
Hallo Bay	--	Small rock, sand	6-27-76	+3.0 to -3.0	c	304.8 1	1
Kukak Bay	--	Small rock, sand	6-30-76	+7.0 to -1.0	c	304.8 1	1
Bumble Bay	--	Medium-small rock,7- sand	9-76	+3.0 to 0.0	c	101.5 1	1
Tugidak Is	--	Small rock, sand	7-11-76	+1.0 to - 1.0	c	304.8 1	1
Dakavak Bay	--	Small rock, sand	7-26-76	+4.0 to -1.0	c	304.8 1	1
Kashvik Bay	--	Medium-small rock,8-10-76 sand		+5.0 to -1.0	c	101.5 1 304.8 1	1
Alinchak Bay	--	Sand	8-24-76	+3.0 to +1.0	c	203.2 1 304.8 1	1

* Sampling Method: A = Arrow, Q = Quadrat Collection, V = Visual Enumeration, C = Core.

Table 3. Presence (x) and absence of species at rocky intertidal sites in the Kodiak area.

	Chirikof Island	Cape Sitkinak	Sud Island	Sundstrom Island	Cape Kaguyak	Three Saints Bay	Lagoon Point	Low Cape	Dolina Point
CHLOROPHYTA									
Ulothrix sp.		X	X						
Ulothrix flacca							X		
Monostroma sp.	(	X	X	X	X	X	X		X
Monostroma fuscum	(		X	X	X				
Monostroma zostericola	(		X	X					
Enteromorpha compressa				X					
Enteromorpha linza	(
Ulva sp.	(	X	X			X	X		
Ulva fenestrata	(
Ulva lactuca	(			X					
Ulva rigida	(
Prasiola meridionalis			X						
Rosenvingiella constricta			X						
Schizogonium murale			X						
Rhizoclonium sp.							X		
Lola lubrica	(				X	X			
Chaetomorpha S.P.					X				
Cladophora sp.					X				
Cladophora seriacea					X				
Spongomorpha sp.		X					X		
Spongomorpha arcta		X					X		
Spongomorpha coalita		X							
Spongomorpha spinescens	(	X	X	X	X	X			X
BACILLARIOPHYCEAE	(	X		X	X				X
PHAEOPHYTA									
Ectocarpaceae			X						
Ectocarpus sp.	X		X						
Ectocarpus similis			X			X			
Pylaiella littoralis	X		X			X			
Ralfsia sp.									
Ralfsia fungiformis	(		X	X					
Elachista fucicola			X	X					
Saundersella simplex	X								
Analipus japonicus	X			X					
esmaestia aculeata	X								X
Soranthra ulvoidea	X		X	X					
Melanosiphon intestinale	X								
Petalonia sp.				X					
Petalonia fasciata			X						
Colpomenia bulbosa		X							

Table 3. continued

	Chirikof Island	Cape Sitkinak	Sud Island	Sundstrom Island	Cape Kaguyak	Three Saints Bay	Lagoon Point	Low Cape	Dolina Point
Phaeophyta--Cont.									
Phaeostrophion Irregular			X	X					
Scytosiphon lomentaria	X				X		X		
Scytosiphon sp.	X								
Coilodesme sp.	X								
Coilodesme polygnampta	X								
Agarum sp.	X								
Hedophyllum sessile				X					
Laminariaceae	X		X				X		
Laminaria sp.	X	X	X	X			X	X	
Laminaria dentigera				X					X
Laminaria groenlandica					X		X		
Laminaria longipes	X		X	X					
Laminaria yezoensis	X		X	X					
laria sp.	X		X	X	X	X	X		X
Alaria crisp									
Alaria fistulosa			X						
Alaria marginata	X		X			X			
Alaria nana			X		X				X
Alaria praelonga				X					
Alaria pylaia			X						
Alaria taeniata	X		X	X			X		
Alaria tenuifolia									
Fucus distichus	X	X	X	X	X	X	X	X	X
RHODOPHYTA									
Bangia fuscopurpurea					X		X		
Porphyra sp.	X		X	X	X	X	X	X	X
Acrochaetium Sp.	X		X	X		X			
Cryptonemiales									
Cryptosiphonia sp.		X							
Cryptosiphonia woodii			X	X			X	X	X
Dumontia incrassata									X
Endocladia sp.									X
Endocladia muricata	X		X			X	X	X	X
Gloiopeltis furcata			X		X				
Petrocelis sp.				X			X		
Petrocelis franciscana			X						
Petrocelis middendorffii				X					
Corallinaceae	X		X						
Tenarea sp.									
Mesophyllum lamellatum			X						
Bossiella sp.			X	X					

Table 3. Continued

	Chirikof Island	Cape Sitkinak	Sud Island	Sundstrom Island	Cape Kaguyak	Three Saints Bay	Lagoon Point	Low Cape	Dolina Point
Rhodophyta--Cont.									
<i>Bossiella chiloensis</i>	X		X	X		X			
<i>Bossiella plumosa</i>	X		X	X		X			
<i>Corallina</i> sp.	X		X	X		X			
<i>Corallina vancouveriensis</i>			X	X		X			
<i>Lithothamnion</i> sp.				X		X	X	X	
Cryptonemiaceae			X						
<i>Cryptonemia ovalifolia</i>		X					X	X	
<i>Callophyllis</i> S. P.			X	X		X			
<i>Callophyllis flabellulata</i>			X	X		X			
<i>Callophyllis pinnata</i>			X						
<i>Ahnfeltia</i> sp.	X	X							
<i>Ahnfeltia plicata</i>	X	X	X	X			X		
Gigartinaceae				X					
<i>Gigartina</i> sp.	X		X	X					X
<i>Gigartina papillata</i>	X	X	X						
<i>Gigartina latissima</i>									
<i>Gigartina stellata</i>	X	X		X	X	X			
<i>Iridaea</i> sp.	X		X	X		X	X		X
<i>Iridaea cornucopia</i>	X	X	X	X	X	X	X		
<i>Iridaea heterocarpa</i>		X			X				X
<i>Iridaea punicea</i>							X		
<i>Rhodoglossum californicum</i>			X						
<i>Fauchea laciniata</i>			X						
<i>Halosaccion</i> sp.	X								
<i>Halosaccion grandiforme</i>		X	X	X	X	X			
<i>Halosaccion saccatum</i>	X								
<i>Rhodymenia</i> sp.			X			X	X		
<i>Rhodymenia palmata</i>	X	X	X	X	X				X
<i>Rhodymenia palmata</i> f. <i>sarnie</i>					X		X		
<i>Rhodymenia pertusa</i>	X		X						
Ceramiceae			X		X		X		
<i>Antithamnion</i> sp.				X					
<i>Callithamnion</i> S. P.						X			
<i>Callithamnion pikeanum</i>				X		X			
<i>Pleonosporium</i> sp.						X	X		
<i>Ceramium</i> S. P.									X
<i>Ceramium pacificum</i>									X
<i>Microcladia borealis</i>	X		X	X					X
<i>Microcladia coulteri</i>	X		X	X					
<i>Ptilota</i> sp.	X	X	X	X	X	X	X	X	X
<i>Ptilota filicina</i>	X		X						
<i>Ptilota tenuis</i>		X	X		X				

Table 3. Continued

	Chirikof Island	Cape Sitkinak	Sud Island	Sundstrom Island	Cape Kaguyak	Three Saints Bay	Lagoon Point	Low Cape	Dolina Point
Rhodophyta--Cont.									
<i>Neoptilota</i> sp.	X		X		X				
<i>Neoptilota asplenioides</i>	X		X	X					
<i>Neoptilota hypnoides</i>			X						
Delesseriaceae			X						
<i>Tokiodadendron bullata</i>	X			X					
<i>Phycodrys riggii</i>	X		X		X		X		X
Rhodomelaceae	X		X						
<i>Polysiphonia</i> sp.							X		
<i>Pterosiphonia</i> sp.	X		X						
<i>Pterosiphonia bipinnata</i>	X		X	X	X				
<i>Pterosiphonia dendroidea</i>			X						
<i>Pterosiphonia gracilis</i>							X		
<i>Rhodomela</i> sp.		X							X
<i>Rhodomela larix</i>			X	X	X		X		X
<i>Odonthalia</i> sp.	X		X	X	X				X
<i>Odonthalia aleutica</i>				X					
<i>Odonthalia floccosa</i>	X	X	X		X	X	X	X	X
<i>Odonthalia kamschatica</i>					X				
<i>Odonthalia lyallii</i>		X							
<i>Odonthalia washingtoniensis</i>	X	X		X		X			X
ANTHOPHYTA									
Potamogetonaceae	X		X	X					
<i>Phyllospadix</i> sp.		X							X
<i>Phyllospadix scouleri</i>									X
<i>Phyllospadix serrulatus</i>	X								
PORIFERA									
Demospongia					X	X	X	X	X
<i>Halichondria panicea</i>	X		X	X					
<i>Haliclona permollis</i>			X						
CNIDARIA									
Hydroidea		X	X		X	X	X		X
<i>Eudendrium</i> sp.					X				
<i>Eudendrium annulatum</i>			X						
<i>Abietinaria</i> sp.					X				
Anthozoa	X	X	X	X	X	X	X	X	A
<i>Anthopleura</i> sp.									
<i>Tealia</i> sp.							X		
<i>Tealia crassicornis</i>						X			

Table 3. Continued

	Chirikof Island	Cape Sitkinak	Sud Island	Sundstrom Island	Cape Kaguyak	Three Saints Bay	Lagoon Point	Low Cape	Dolina Point
TURBELLARIA	x	x	x	x	x	x	x	x	x
RHYNCHOCOELA		x			x		x	x	x
<i>Empiectionema gracile</i>	x		x	x		x			
NEMATODA	x		x	x	x	x	x		
ANNELIDA									
<i>Polychaeta</i>		x			x		x	x	x
<i>Arctonoe</i> sp.				x					
<i>Halosydna brevisetosa</i>			x						
<i>Harmothoe imbricata</i>				x					
<i>Phloe minuta</i>			x	x		x			
<i>Paleanotus bellis</i>						x			
<i>Dysponetecus</i> SD.				x					
<i>Phyllodocidae</i>	x		x	x					
<i>Anaitides</i> sp.	x		x	x					
<i>Eteone</i> sp.	x					x			
<i>Eteone longa</i>	x		x	x		x			
<i>Eulalia</i> sp.	x		x	x		x			
<i>Eulalia viridis</i>			x						
<i>Eulalia bilineata</i>	x		x	x					
<i>Eulalia quadrioculata</i>	x		x	x		x			
<i>Syllidea</i> —	x		x	x		x			
<i>Autolytus</i> sp.				x		x			
<i>Autolytus cornutus</i>						x			
<i>Autolytus prismaticus</i>			x						
<i>Autolytus trilineatus</i>						x			
<i>Autolytus convolutes</i>						x			
<i>Syllis</i> SD.				x		x			
<i>Typosyllis</i> sp.	x		x	x		x			
<i>Typosyllis alternata</i>	x		x	x		x			
<i>Typosyllis armillaris</i>			x	x		x			
<i>Typosyllis pulchra</i>	x			x		x			
<i>Typosyllis stewarti</i>				x		x			
<i>Typosyllis fasciata</i>				x					
<i>Typosyllis adamantea</i>			x	x		x			
<i>Typosyllis hyalina</i>				x					
<i>Eusyllis</i> SD.							x		
<i>Eusyllis assimilis</i>				x					

Table 3. Continued

	Chirikof Island	Cape Sitkinak	Sud Island	Sundstrom Island	Cape Kaguyak	Three Saints Bay	Lagoon Point	Low Cape	Dolina Point
Imnelida--Cont.									
Exogone sp.	x		x						
Exogone gemmifera	x		x			x			
Exogone lourei			x	x		x			
Sphaerosyllis sp.	x		x	x					
Sphaerosyllis pirifera	x		x	x		x			
Sphaerosyllis brandhorsti			x						
Syllides iaponica	x		x	x					
Nereidae				x					
Nereis sp.	x		x	x		x			
Nereis pelagica	x		x	x		x			
Nereis vexillosa	x					x			
Nereis zonata	x		x						
Nereis grubei				x					
Sphaerodoridium gracilis				x					
Sphaerodoridium papillifera						x			
Sphaerodoropsis minutum	x			x		x			
Glycera capitata	x		x			x			
Onuphis iridescent			x						
Eunicidae			x						
Eunice valens				x					
Lumbrineris sp.	x		x	x					
Lumbrineris zonata			x	x					
Lumbrineris inflata	x		x	x					
Protodorvillea gracilis				x					
Naineris sp.	x		x			x			
Naineris quadricuspida	x		x			x			
Naineris laevigata	x			x					
Paraonidae			x			x			
Spionidae			x	x					
Polydora sp.	x		x	x					
Polydora ciliata	x			x					
Prionospio malmgreni						x			
pio-filicornis			x	x					
Boccardia SD*	x		x	x					
Boccardia columbiana				x					
Boccardia natrix	x		x	x					
Boccardia proboscidea			x						
Pygospio sp.						x			
Cirratulus SD	x			x		x			
Cirratulus cirratus	x			x		x		--	

Table 3. Continued

	Chirikof Island	Cape Sitkinak	Sud Island	Sundstrom Island	Cape Kaguyak	Three Saints Bay	Lagoon Point	Low Cape	Dolina Point
Annelida--Cont.									
Tharyx sp.	X		X	X					
Capitellidae			X						
Capitella capitata	X		X	X		X			
Maldanidae			X						
Nicomache sp.	X								
Nicomache personata	X								
Owenia fusiformis						X			
Sabellariidae			X						
Idanthyrus armatus			X						
Ampharetidae			X	X					
Asabellides littoralis				X					
Terebellidae			X						
Nicolea zostericola			X						
Polycirrus medusa	X			X		X			
Sabellidae	X		X	X		X			
Chone gracilis	X		X	X		X			
Chone infundibuliformis			X						
Potamilla neglecta			X	X					
Pseudopotamilla reniformis			X	X					
Schizobranchia insignis				X					
Amphiglena pacifica	X		X	X		X			
Fabricia sabella	X		X	X		X	X		
Fabricia pacifica						X			
Fabricia crenicollis	X		X	X		X			
Pseudosabellides littoralis	X		X	X					
Spirorbis sp.					X		X		
Spirorbis spirillum							X		
Dexiospira spirillum	X		X	X		X			
Ligochaeta			X			X	X		
Enchytraeidae	X		X	X		X			
Hirudinea	X		X	X					
POLYPLACOPHORA									
Cynoplax dentiens				X		X			
Lepidochiton sharpei				X					
Tonicella lineata			X	X		X	X		
Katharina tunicata	X		X	X	X	X	X		X
Mopalia ciliata				X			X		
Mopalia mucosa				X		X			
Schizoplax brandtii	X		X	X	X	X		X	

Table 3. Continued

	Chirikof Island	Cape Sitkinak	Sud Island	Sundstrom Island	Cape Kaguyak	Three Saints Bay	Lagoon Point	Low Cape	Dolina Point
<i>Mytilus edulis</i>	X		X	X	X	X	X	X	X
<i>Musculus</i> Sp.	X		X	X					
<i>Musculus niger</i>			X						
<i>Musculus discors</i>	X			X	X			X	X
<i>Musculus vernicosus</i>	X		X	X					
<i>Musculus olivaceus</i>				X		X			
<i>Modiolus modiolus</i>				X	X				X
<i>Pododesmus macroschisma</i>							X		
<i>Mysella compressa</i>							X		
<i>Mysella planata</i>						X			
<i>Turtonia minuta</i>		X			X			X	X
<i>Turtonia occidentalis</i>	X		X	X		X			
<i>Transennella</i> Sp.							X		
<i>Protothaca staminea</i>	X		X	X		X	X	X	X
<i>Hiatella arctica</i>	X		X	X	X	X	X	X	X
GASTROPODA									
Acmaeidae									
<i>Acmaea mitra</i>			X		X		X		
<i>Collisella</i> sp.	X			X			X		
<i>Collisella pelta</i>	X	X	X	X	X	X	X	X	X
<i>Collisella digitalis</i>	X		X	X	X	X	X	X	
<i>Collisella instabilis</i>							X		
<i>Notoacmea scutum</i>	X	X		X	X	X	X	X	X
<i>Notoacmea persona</i>		X					X		X
<i>Notoacmea fenestrata</i>								X	
<i>Cryptobranchia alba</i>						X			
<i>Margarita</i> sp.			X		X				
<i>Margarites helioides</i>	X	X		X	X	X	X	X	X
<i>Margarites pupillus</i>			X	X	X	X	X	X	
<i>Margarites beringensis</i>				X					
<i>Homalopoma</i> sp.				X					
<i>Littorina</i> sp.			X				X		
<i>Littorina sitkana</i>	X	X	X	X	X	X	X	X	X
<i>Littorina aleutica</i>	X		X						
<i>Littorina scutulata</i>	X		X			X			
<i>Littorina saxatilis</i>							X		
<i>Haloconcha reflexa</i>	-X		X	X					
<i>Lacuna</i> sp.		X		X	X		X		X
<i>Lacuna carinata</i>									X

Table 3. Continued

	Chirikof Island	Cape Sitkinak	Sud Island	Sundstrom Island	Cape Kaguyak	Three Saints Bay	Lagoon Point	Low Cape	Dolina Point	
Gastropoda--Cont.										
<i>Lacuna marmorata</i>	x	x	x	x	x	x		x	x	
<i>Lacuna vincta</i>	x		x	x		x				
<i>Ivinia compacta</i>			x	x			x			
<i>Cingula</i> sp.				x						
<i>Barleeia</i> sp.	x		x	x		x				
<i>Bittium munitum</i>							x			
<i>Cerithiopsis</i> sp.	x		x	x		x		x		
<i>Melanella micrans</i>				x						
<i>Trichotropis insignis</i>							x			
<i>Trichotropis cancellata</i>									x	
<i>Velutina velutina</i>				x	x	x				
<i>Fusitriton oregonensis</i>					x		x			
<i>Ocenebra interfossa</i>								x	x	
<i>Trophonopsis pacificus</i>							x			
<i>Nucella</i> sp.			x	x		x		x	x	
<i>Nucella canaliculata</i>						x	x		x	
<i>Nucella lamellosa</i>				x	x	x	x			
<i>Nucella lima</i>	x	x	x	x		x	x	x	x	
<i>Buccinum</i> sp.		x	x			x				
<i>Buccinum baeri</i>	x	x	x	x	x	x	x	x	x	
<i>Searlesia dira</i>	x		x	x	x		x	x		
<i>Amphissa columbiana</i>							x	x		
<i>Odostomia</i> sp.	x	x	x	x		-x				
<i>Odostomia elsa</i>							x			
<i>Cylindna occultus</i>			x							
<i>Acanthodoris</i> sp.						x				
<i>Hermisenda</i> sp.							x			
<i>Onchidella borealis</i>			x	x		x	x			
<i>Siphonaria</i> sp.				x						
<i>Siphonaria thersites</i>			x	x	x	x	x			
ARACHNIDA										
Acarina			x	x		x				
<i>Halacaridae</i>	x		x	x	x	x	x			
<i>Pseudoscorpionida</i>			x	x		x	x			
PYCNOGONIDA						x				
<i>Phoxichilidium quadridentat</i>	x									
<i>Phoxichilidium femoratum</i>		x	x	x	x			x		
<i>Ammonothea gracilipes</i>		x								

Table 3. Continued

	Chirikof Island	Cape Sitkinak	Sud Island	Sundstrom Island	Cape Kaguyak	Three Saints Bay	Lagoon Point	Low Cape	Dolina Point
Pycnogonida--Cont.									
<i>Ammothea pribilofensis</i>	x	x	x	x	x			x	
<i>Achelia chelata</i>									x
CRUSTACEA									
Platycopa	x		x						
Harpacticoida	x		x	x		x	x	x	
Thoracica			x	x	x	x			
Balanidae							x		x
<i>Balanus</i> sp.	x	x	x	x		x		x	
<i>Balanus balanoides</i>	x				x	x	x	x	x
<i>Balanus cariosus</i>	x	x	x	x	x	x	x	x	x
<i>Balanus glandula</i>	x		x	x	x	x	x		
<i>Balanus rostratus</i>			x		x				
<i>Chthamalus dalli</i>	x	x	x	x		x	x	x	x
Mysidacea			x						
<i>Archaeomysis grebnitzkii</i>						x			
Cumacea	x						x		
<i>Cumella</i> sp.	x		x						
<i>Cumella vulgaris</i>						x			
Tanidacea	x		x	x		x			
Tanaidae	x		x	x					
<i>Tanais</i> sp.			x						
Isopoda	x		x				x		
Synidotea sp.			x						
<i>Pentidotea resects</i>								x	
<i>Pentidotea wosensenskii</i>	x	x	x	x	x	x	x	x	x
<i>Idothea fewkesi</i>	x		x	x					
Sphaeromatidae	x	x	x			x	x		
<i>Gnori mosphaeroma</i> sp.			x						
<i>Gnori mosphaeroma oregonens</i>	x		x	x	x	x			
<i>Exosphaeroma</i> sp.	x	x	x	x	x		x	x	x
<i>Exosphaeroma ampl i cauda</i>	x		x	x					
<i>Dynamenella sheareri</i>				x		x			
<i>Ianiropsis kincaidi kincai</i>	x		x	x		x	x		
<i>Munna</i> sp.	x	x	x	x		x	x		
<i>Munna stephenseni</i>				x		x			
Anthuridae		x							
Amphipoda	x	x	x	x	x	x	x	x	x
<i>Ampithoe</i> sp.	x		x			x			
<i>Ampithoe rubricatoides</i>				x					

Table 3. Continued

	Chirikof Island	Cape Sitkinak	Sud Island	Sundstrom Island	Cape Kaguyak	Three Saints Bay	Lagoon Point	Low Cape	Dolina Point
Crustacea--Cont.									
<i>Ampithoe similans</i>	X		X	X		X			
<i>Ampithoe lindbergi</i>	X		X	X					
<i>Aoroides</i> sp.									
<i>Aoroides columbiae</i>	X					X			
Calliopidae			X						
<i>Oligochinus lighti</i>	X		X	X		X			
<i>Calliopella pratti</i>	X		X	X					
<i>Corophium</i> sp.	X			X					
<i>Corophium brevis</i>	X			X					
<i>Polycheria osborni</i>				X					
Eusiridae	X		X	X		X			
<i>Accedomoera</i> sp.				X					
<i>Accedomoera vagor</i>	X		X	X					
<i>Paramoera columbiana</i>	X		X	X		X			
<i>Pontogeneia</i> sp.	X		X			X			
Gammaridae	X					X	X		
<i>Anisogammarus</i> sp.	X		X						
<i>Melita</i> sp.	X		X	X		X			
<i>Haustorius</i> sp.						X			
<i>Najna conciliorum</i>	X		X	X		X			
Hyalidae	X		X	X		X			
<i>Allorchestes maleolus</i>						X			
<i>Allorchestes angustus</i>	X		X						
<i>Allorchestes anceps</i>				X		X			
<i>Hyale</i> sp.				X		X			
<i>Hyale rubra</i>	X		X	X		X			
<i>Hyale rubra frequens</i>						X			
<i>Hyale grandicornis</i>				X					
<i>Parallorchestes ochotensis</i>	X		X	X					
<i>Parallorchestes anguipes</i>			X						
<i>Photis</i> sp.			X	X					
<i>Photis brevipes</i>	X			X					
<i>Photis bifurcata</i>			X	X					
Ischyroceridae	X		X	X					
<i>Ischyrocerus</i> sp.	X		X			X			
<i>Ischyrocerus anguipes</i>	X		X	X		X			
<i>Ischyrocerus rhodomelae</i>						X			
<i>Jassa</i> sp.			X						
<i>Jassa pulchella</i>	X		X	X		X			
<i>Anonyx</i> sp.	X		X						
<i>Orchomene</i> sp.	X		X						

Table 3. Continued

	Chirikof Island	Cape Sitkinak	Sud Island	Sundstrom Island	Cape Kaguyak	Three Saints Bay	Lagoon Point	Low Cape	Dolina Point
Crustacea--Cont.									
Orchomene sp.	x		x						
Orchomene minuta			x						
Orchomene lipidula	x		x						
Orchomene obtusa			x						
Pleustidae	x		x	x					
Parapleustes nautilus	x		x	x		x			
Pleustes sp.			x						
Stenopleustes uncigera	x		x			x			
Stenothoidae	x		x	x		x			
Metopella sp.	x								
Talitridae			x						
Caprellidae	x	x	x	x	x	x		x	x
Cercops compactus			x						
Caprella s p	x		x			x	x		
Caprella cristibranchium			x						
Caprella alaskana			x						
Caprella irregularis	x								
Caprella laeviuscula			x					x	
Decapoda			x						
Pagurus sp.		x		x		x	x	x	
Pagurus beringanus				x					
Pagurus hemphilli					x				
Pagurus hirsutiusculus	x	x	x	x	x	x	x	x	x
Pugettia sp.			x						
Pugettia gracilis	x		x	x		x	x		
Cancer sp.	x								
Cancer oregonensis	x		x	x				x	x
Telmessus cheiragonus	x								
INSECTA									
Insects								x	
Collembola							x		
Anurida maritima				x		x			
Diptera			x	x	x	x	x	x	
ulidae			x				x		
Chironomidae			x	x		x	x		
ulicidae			x						
Dolichopodidae							x		
Cicadellidae			x						
Coleoptera			x	x		x			

Table 3. Continued

	Chirikof Island	Cape Sitkinak	Sud Island	Sundstrom Island	Cape Kaguyak	Three Saints Bay	Lagoon Point	Low Cape	Dolina Point
Insects--Cont.									
Staphinidae			X				X		
<i>Amblopusa borealis</i>							X		
SIPUNCULIDA						X			
BRYOZOA									
Bryozoan				X	X	X			
<i>Microporina</i> sp.	X								
<i>Hipposheia hyalina</i>			X	X					
<i>Filicrisia</i> sp.	-			X					
<i>Crisis</i> sp.			X						
Flustrellidae				X					
<i>Flustrella</i> sp.			X						
BRACHIOPODA	X								
ASTEROIDEA									
<i>Henricia</i> sp.	X			X			X		
<i>Henricia sanguinolenta</i>	-			X					
<i>Evasterias trochellii</i>					X				
<i>Leptasterias</i> sp.	X		X	X		X			
<i>Leptasterias hexactis</i>	X	X	X	X	X	X	X	-X	X
ECHINOIDEA									
<i>Strongylocentrotus droebachiensis</i>						X	X		
OPHIUROIDEA						X	X		
<i>Ophiopholis aculeata</i>			X	X	X				
HOLOTHUROIDEA									
<i>Cucumaria</i> sp.			X				X		
<i>Cucumaria pseudocurata</i>	X	X	X	X	X	X	X	X	X
UROCHORDATA									
Urochordata									
<i>Styela clavata</i>									
<i>Aploousobranchia</i>									
<i>Applidium</i> (<i>Amaroucium</i>) <i>clat</i>									

W

TELEOSTEI		Chirikof Island
Cottidae		Cape Sitkinak
Clinocottus embryum	X	Sud Island
Gymnocanthus pistilliger	X	Sundstrom Island
Liparis sp.	X	Cape Kaguyak
	X	Three Saints Ba
	X	Lagoon Point
	X	Low Cape
	X	Dolina point

Table 4. Presence (x) and absence of species at sandy intertidal sites in the Kodiak area.

	Tanner Head	Halibut Bay	Swikshak Beach	Village Beach	Big River Beach	Hallo Bay	Kukak Bay	Bumble Bay	Tugidak Island	Dakavak Bay	Kashvik Bay	Alinchak Bay	Lagoon Point
RHYNCHOCOELA													
Rhynchocoela					X	X	X						
Rineidae		X					X			X			
Cerebratulus californiensis			X	X	X	X	X			X			
NEMATODA													
Nematoda													X
ANNELIDA													
Annelida													X
Polychaeta													X
Anaitides groenlandica				X		X	X						
Eteone longa		X	X			X	X		X	X	X		
Nephtys caeca	X	X	X	X	X	X	X	X			X	X	
Nephtys californiensis		X	X	X	X		X		X	X	X	X	
Glycinda picta		X					X		X		X		
Haploscoloplos elongatus		X	X	X	X	X	X		X		X		
Scolecopsis squamatus	X	X	X	X	X	X	X	X		X	X	X	
Ophelia assimilis	X	X		X	X			X	X	X	X		
Travissia brevis					X								
Cistenides brevicoma				X		X							
Fabricia sabella													X
Oligochaeta													X
PELECYPODA													
Mytilus edulis	X												X
Clinocardium nuttallii	X					X	X						
Protothaca staminea							X						
Spisula polynema	X		X	X	X		X				X		
Macoma calcarea							X						
Macoma loveni							X						
Macoma lama		X	X		X	X	X				X	X	
Macoma yoldiformis							X						
Macoma nasuta	X												
Macoma balthica						X	X				X		
Tellina lutes					X								
Tellina nucleoides			X										
Siliqua patula		X	X	X	X	X	X		X		X	X	
Siliqua alta		X	X		X	X	X						
GASTROPODA													
Littorina sitkana	X												

Table 4. Continued

	Tanah...	Halbut Bay	Swikshak Bay	Village Bay	Big River Bay	Hallo Rav	Kukal Bay	Bumhlo Bay	Tugidal Bay	K Bay	Kashvil Bay	Alinchal Bay	Lagoon Point
ISOPODA													
Isopod	X				X	X							
Cirolanidae													
Cirolana sp.	X												
AMPHIPOD													
Eohaustorius	X	X		X	X	X	X			X	X	X	X
TELEOSTEI													
Ammodytes hexapterus	X		X	X	X					X	X		

Table 5. Presence (x) and absence of species at muddy intertidal sites in the Kodiak area.

	South Kodiak Lagoon
RHYNCHOCOELA	
Rhynchocoela	x
ANNELIDA	
Polychaeta	x
Eteone longis	x
Nephtys caeca	x
Fabricia sabella	x
Oligochaeta	x
PELECYPODA	
Mytilus edulis	x
Macoma calcarea	x
Macoma balthica	x
GASTROPODA	
Turtonia occidentals	x
AMPHIPODA	
Amphipoda	x

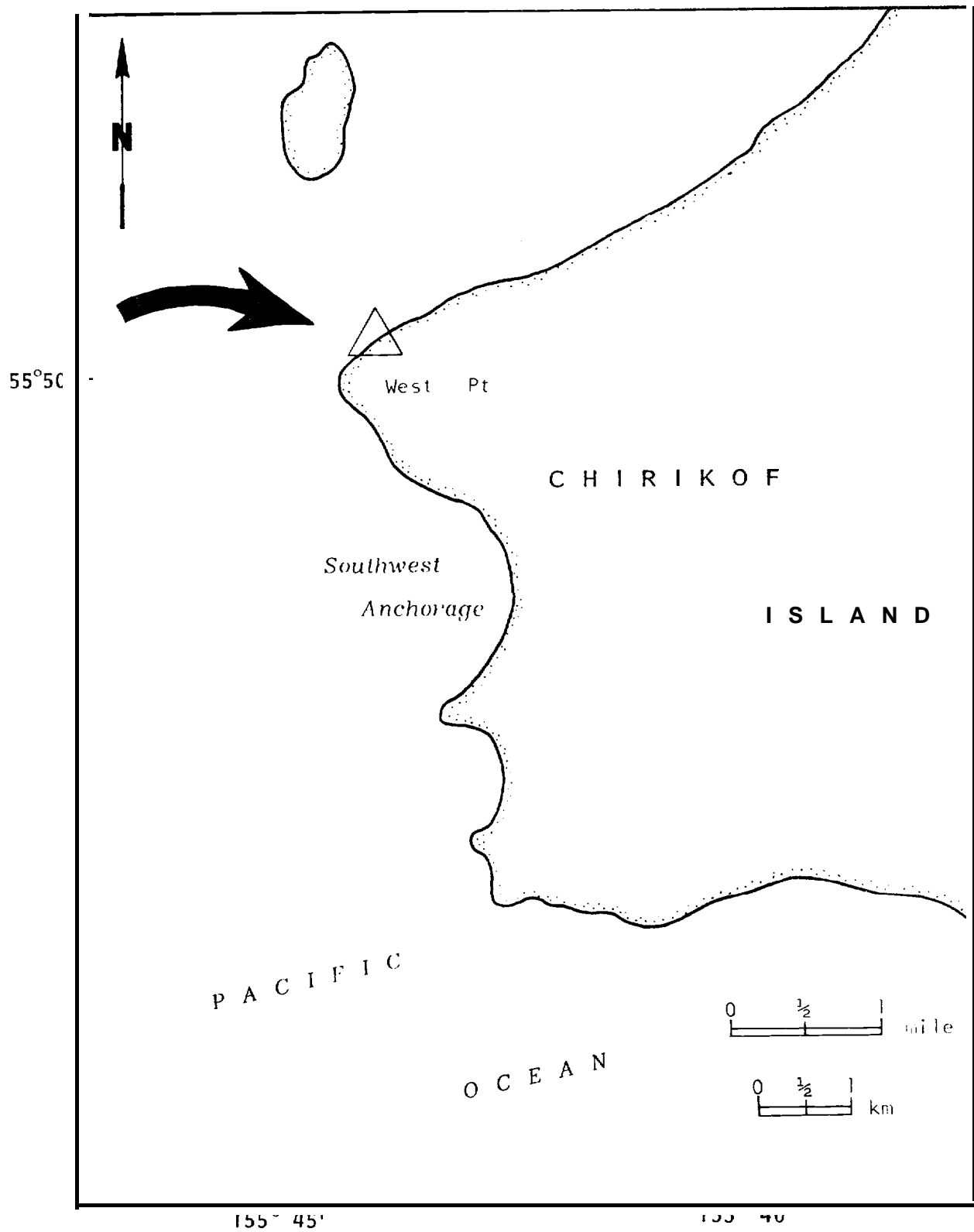


Figure 15. Chirikof Island site.



Figure 16. Chirikof Island. View along transect line looking shoreward toward sand beach.

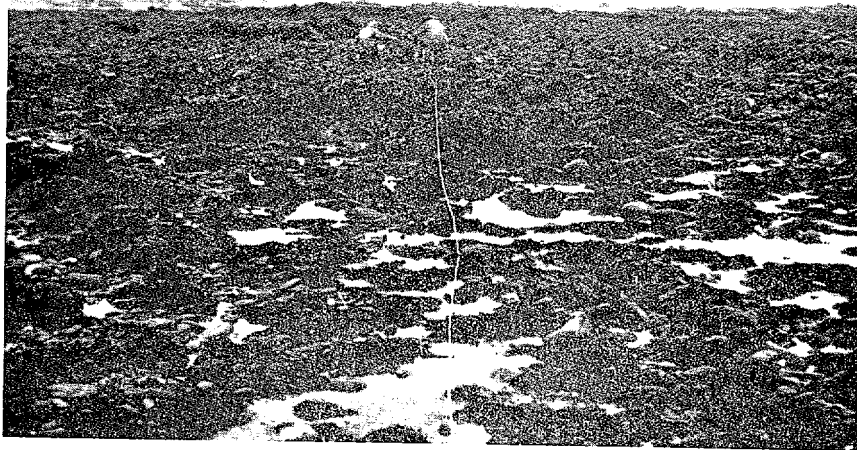
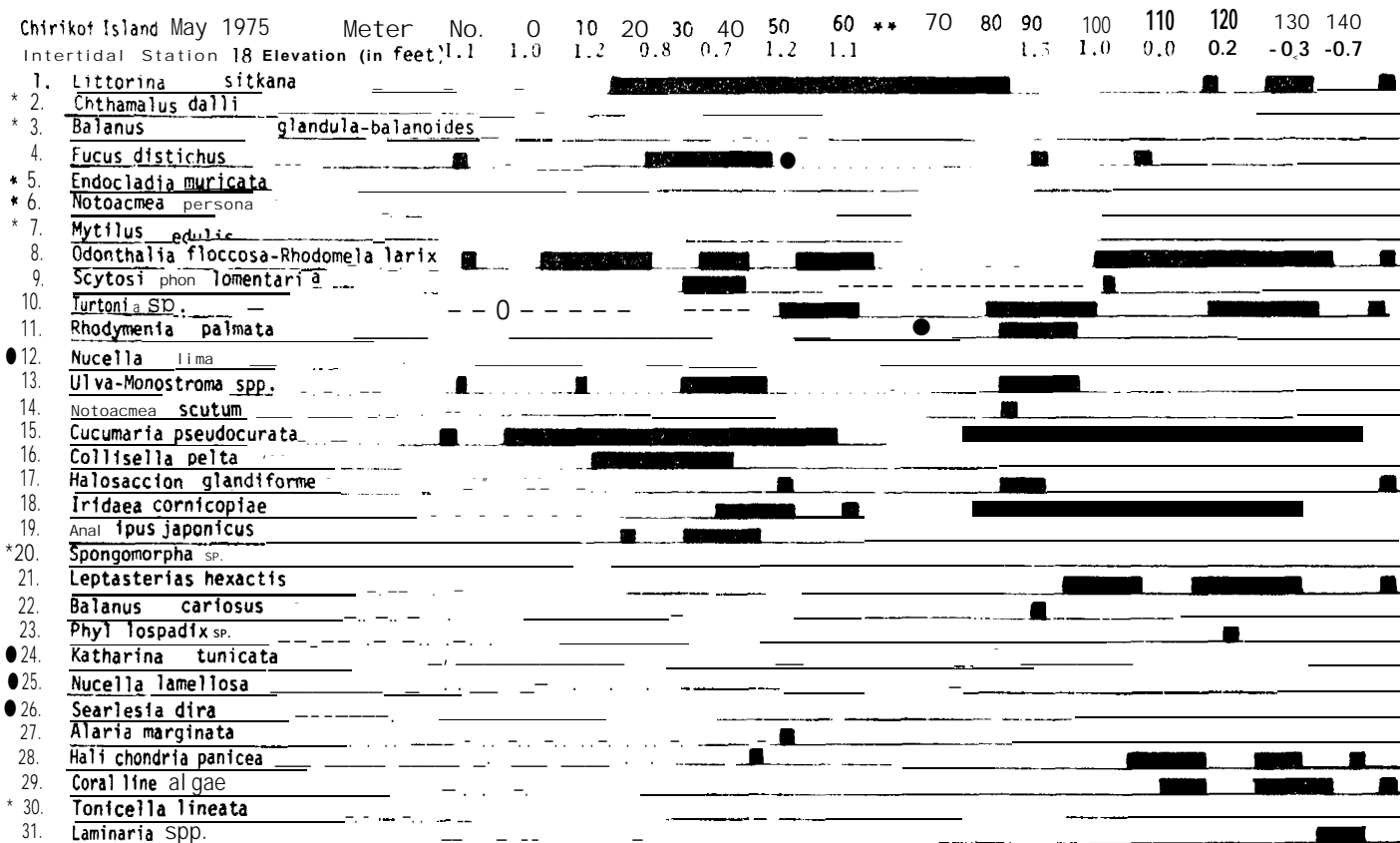


Figure 17. Chirikof Island, View along transect line looking toward the water.



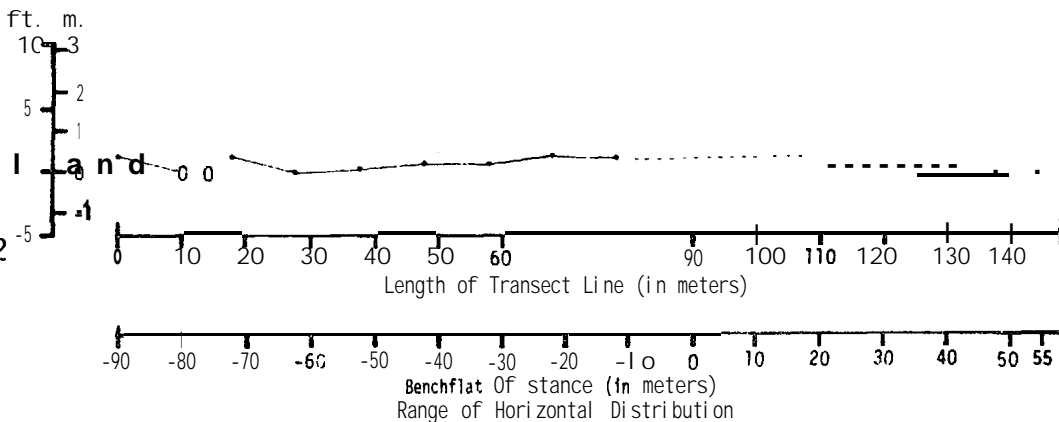
Figure 18. Chirikof Island, Sampling part of the reef using the arrow method.



• Species not present in quadrat collections on this transect line.

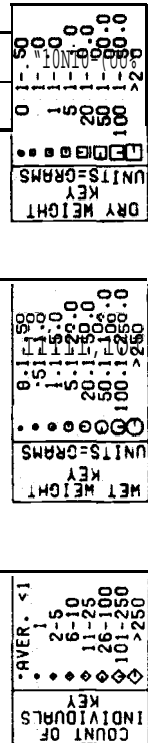
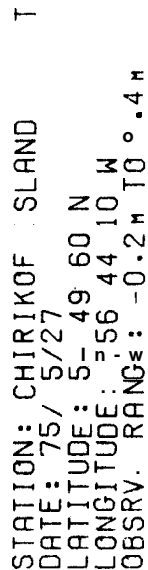
● *no samples collected for meters 65, 70, 75, and 80.

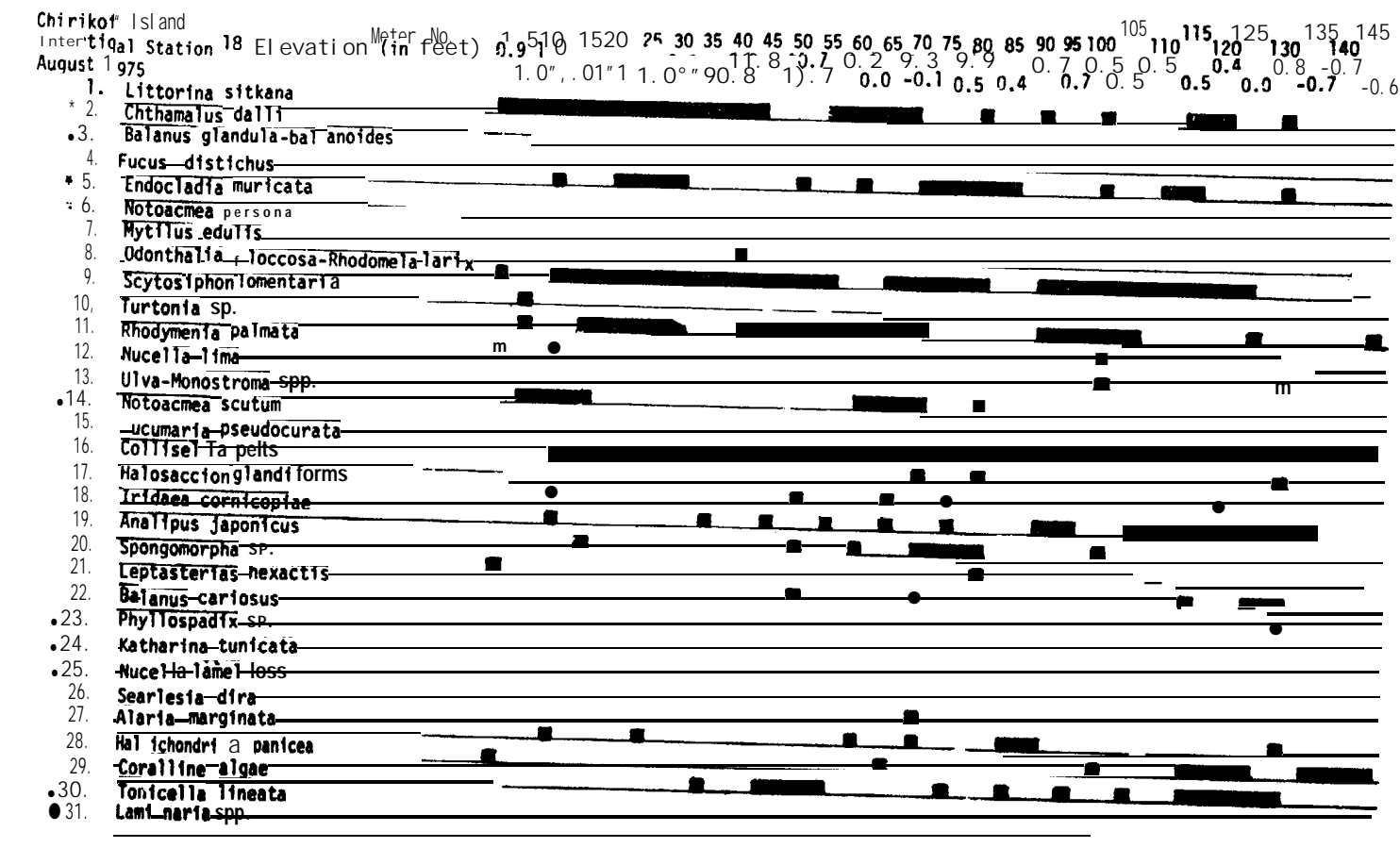
Fig. 19. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m² quadrats along transect line 1.



ALGAE

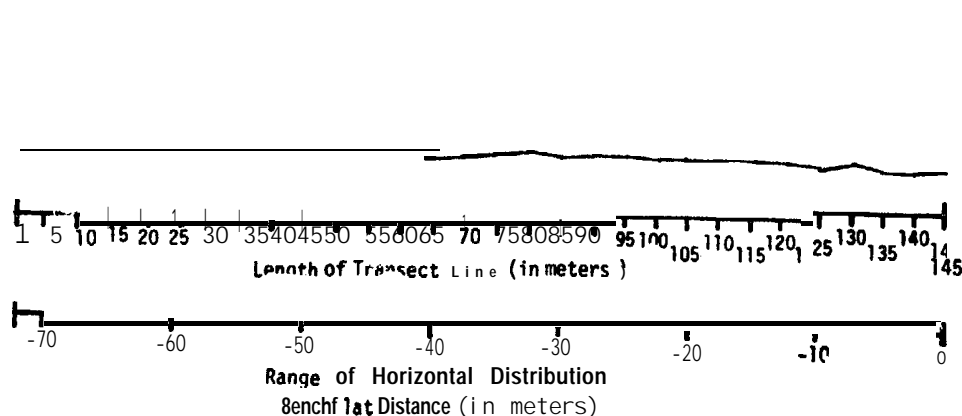
SELECT[®] INVERTEBRATES



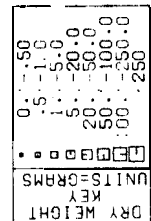
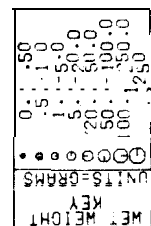
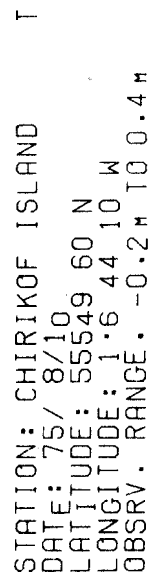
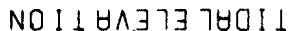


• Species not present in quadrat 't. M.
collections on this transect line. 10-3

Fig. 21. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m² quadrats along transect line 1.



ALGAE



midrib and sporophylls persisting. Farther along the line in an area with fewer cobbles, but with pebbles and sand, the Alaria began to thin out and most of it was eroded. Much of the Fucus was sterile. The distribution of all organisms was patchy.

Only a few differences were obvious between the May and August sampling periods. In May we saw a very heavy cover of drift material, mostly decaying algae, at the high tide line. In August the drift material was approximately 10% of what it had been in May. In August we found more species of brown algae (e. g., Anelopus, Melanosiphonia) than in May and noted a heavy cover of bladed green algae (family Ulvales) at the upper end of the transect line.

Cape Sitkinak (Trinity Islands)

Cape Sitkinak, on Sitkinak Island, is the easternmost point in the Trinity Island group (Figure 23). It lies in a highly exposed location, subject to the full force of southeasterly Pacific storms. Heavy tide rips in Sitkinak Strait and the full exposure to waves and winds make it a turbulent area.

The beach (Figures 24 and 25) is bounded by high bluffs which rise from a sandy slope above high water. The intertidal area is part of an extensive, almost flat reef area which extends far offshore. The upper part of the intertidal area is covered with large and small boulders. The lower part is exposed bedrock and is covered with pockets of sand in some places. Owing to the very slight gradient almost the entire lower area is covered by water, even when the tide is out. Large tide pools abound and are occupied by extensive beds of surf grasses (Phyllospadix serrulatus) and kelps (Alaria and Laminaria).

During May 1976 we studied the area using two transect lines. Quadrats along both lines were visually enumerated to determine percent coverage and species composition of algae. Along the first line we also collected quantitative samples. At the time the lines were laid, only the upper portions of the intertidal area were exposed. As the tide continued to recede, several hundred more meters of beach were exposed. This area was investigated qualitatively but it was not possible to make systematic quantitative collections during the short period of time the lower areas were exposed. Thus, the area dominated by kelp was not sampled.

A comparison of the two lines indicated that similar organisms were present at both locations. Since neither of the lines passed through the large area of Phyllospadix, there were several sources of variability which were not sampled.

Algal cover (Figures 26 and 27) was not heavy along the upper third of the transect. This was an area of small to medium boulders which are moved during storms. Along transect 1, where collections were made, Odonthalia and Rhodomela, which often occur together and may be difficult to differentiate, were the most abundant algae. Two other algae which often occur together, Gigartina and Iridaea, were the next most abundant in the quadrat collections. Phyllospadix were collected in only one quadrat along the transect but were abundant in the flat reef area beyond the end of the transect. Laminaria were not collected along the transect but were also abundant in the flat reef area.

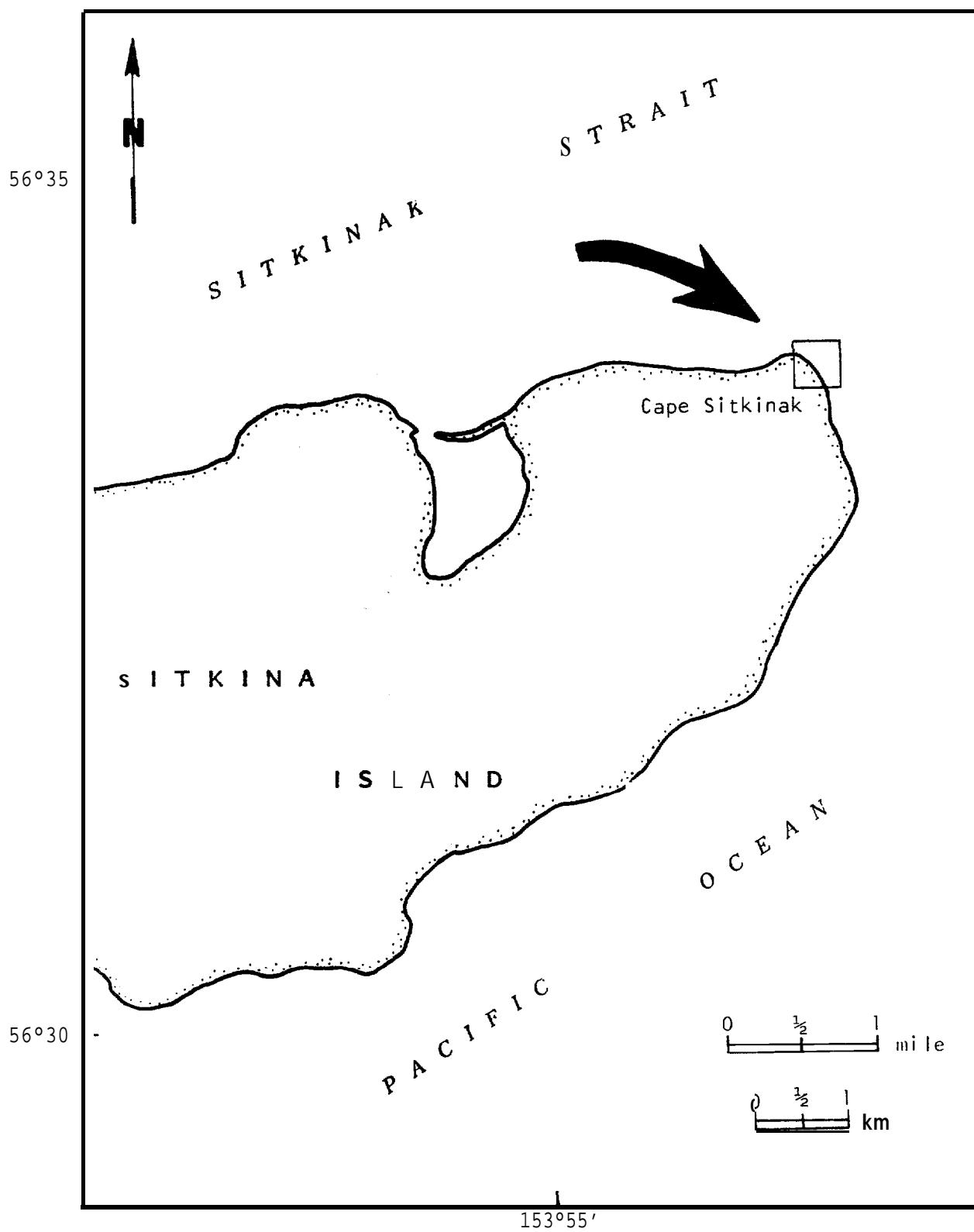


Figure 23. Cape Sitkinak site.

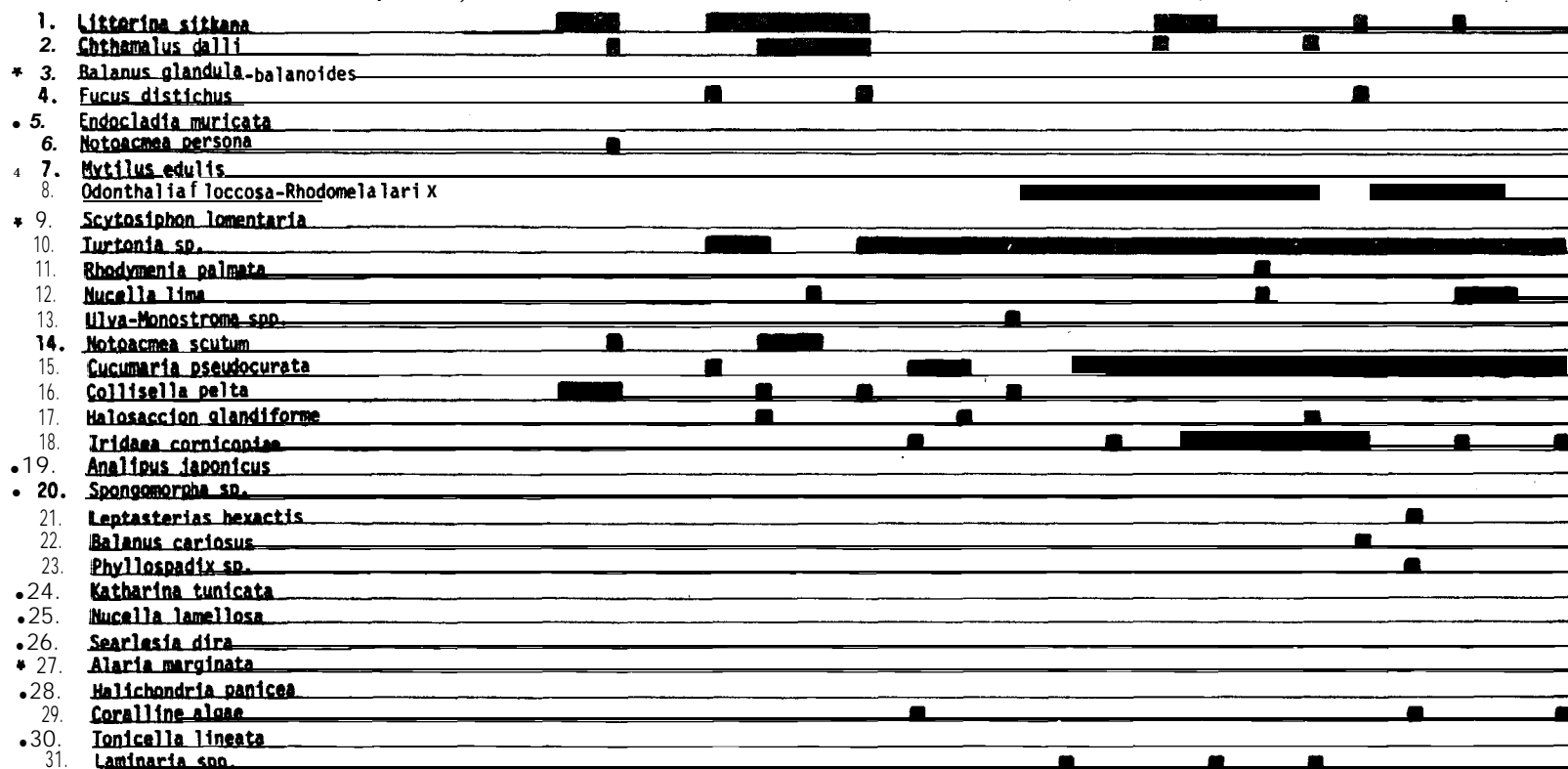


Figure 24. Cape Sitkinak, Sitkinak Island. General view of sampling area. Intertidal sampling began where the surveyors are standing.



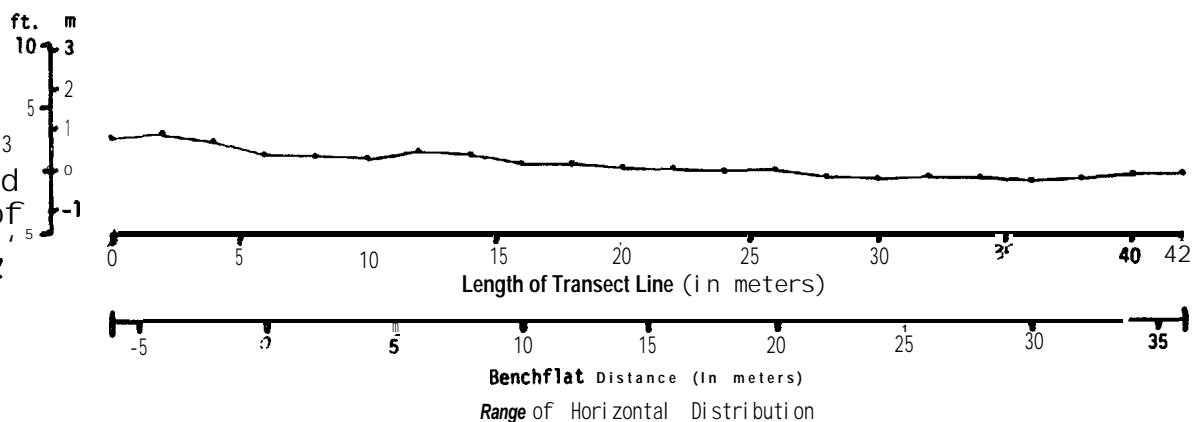
Figure 25. Cape Sitkinak, Sitkinak Island. General view of sampling area looking toward the upper part of the beach. Note standing water and Laminaria in foreground.

Cape Sitkinak May 1976 Meter No. 0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 ?
 Intertidal station 37 Elevation (in feet) 2.6 3.0 2.4 1.3 1.2 1.1 1.8 1.4 0.9 0.9 0.4 0.3 0.1 0.2 -0.1 -0.3 -0.1 -0.1 -0.5 -0.2 0.0 0.0



• Species not present in quadrat collections on this transect line.

Fig. 26. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m² quadrats along transect line 1₀.



Invertebrate populations were quite low (Figures 26 and 27). Mussels (Mytilus edulis) were almost entirely absent. Predatory snails (Nucella lamellosa, Searlesia), starfishes, and urchins were also generally missing. Even forms which were present at almost all of our sampling sites, such as chitons, sponges, and the barnacle Balanus cariosus, were absent or uncommon at Cape Sitkinak. Relatively common invertebrates included limpets, hermit crabs, sea cucumbers, and amphipods.

Sud Island (Barren Islands)

Sud Island (Figure 28) is one of the precipitous, windswept Barren Islands just below the entrance to Cook Inlet. These islands are exposed to the mixing of atmospheric and oceanic forces between Cook Inlet, Shelikof Strait, and the northwestern Gulf of Alaska. Winds there are stronger than in nearby areas, and heavy tide rips and ocean currents occur throughout the Barren Islands. NMFS divers commented that some of the densest communities of subtidal algae encountered in Alaska are present in this highly mixed and turbulent area (Louis Barr, personal communication).

Much of the littoral area is either bedrock or bedrock overlaid by large boulders. The site we sampled, on the northern side of Sud Island, was composed of large boulders which almost completely covered a substrate of moderately sloping bedrock. One transect line and the arrow method were used to collect quantitative samples in May 1975, and two transect lines in August (Figures 29 and 30).

Algal cover (Figures 31-36) was very dense in the intertidal areas. The middle and upper areas were dominated by heavy growths of Fucus distichus, the lower area by well-developed growths of the red algae Rhodomenia palmata, Callophyllis sp. (or possibly R. palmata f. sarniensis), and Iridaea sp. The sublittoral fringe had lush populations of Alaria sp. and Laminaria sp.

Among the invertebrates (Figures 31-36), Littorina sitkana was common in the upper zones and Balanus cariosus and Halichondria panicea were abundant in the lower zones. Mytilus edulis populations were confined to the protected sides of large boulders or bedrock outcropping and did not generally occur where the transect lines were laid. Greater numbers of Mytilus were found in collections from transect 2, August 1975, possibly because the transect had a greater vertical range and was more hummocky than the other transects. Limpets, chitons, predatory snails, and starfishes were either absent or scarce.

Sundstrom island

Sundstrom Island lies south of Kodiak Island between the Trinity Islands and Cape Trinity (Figure 37). The beach is basaltic bedrock with deep indentations. At the head of the rocky area there is a narrow strip of black sand beach which rises abruptly to steep rocky bluffs, some of which are covered with grass.

Sundstrom Island was quantitatively sampled in May and August 1975 and qualitatively surveyed in May 1976 (Figures 38-44).

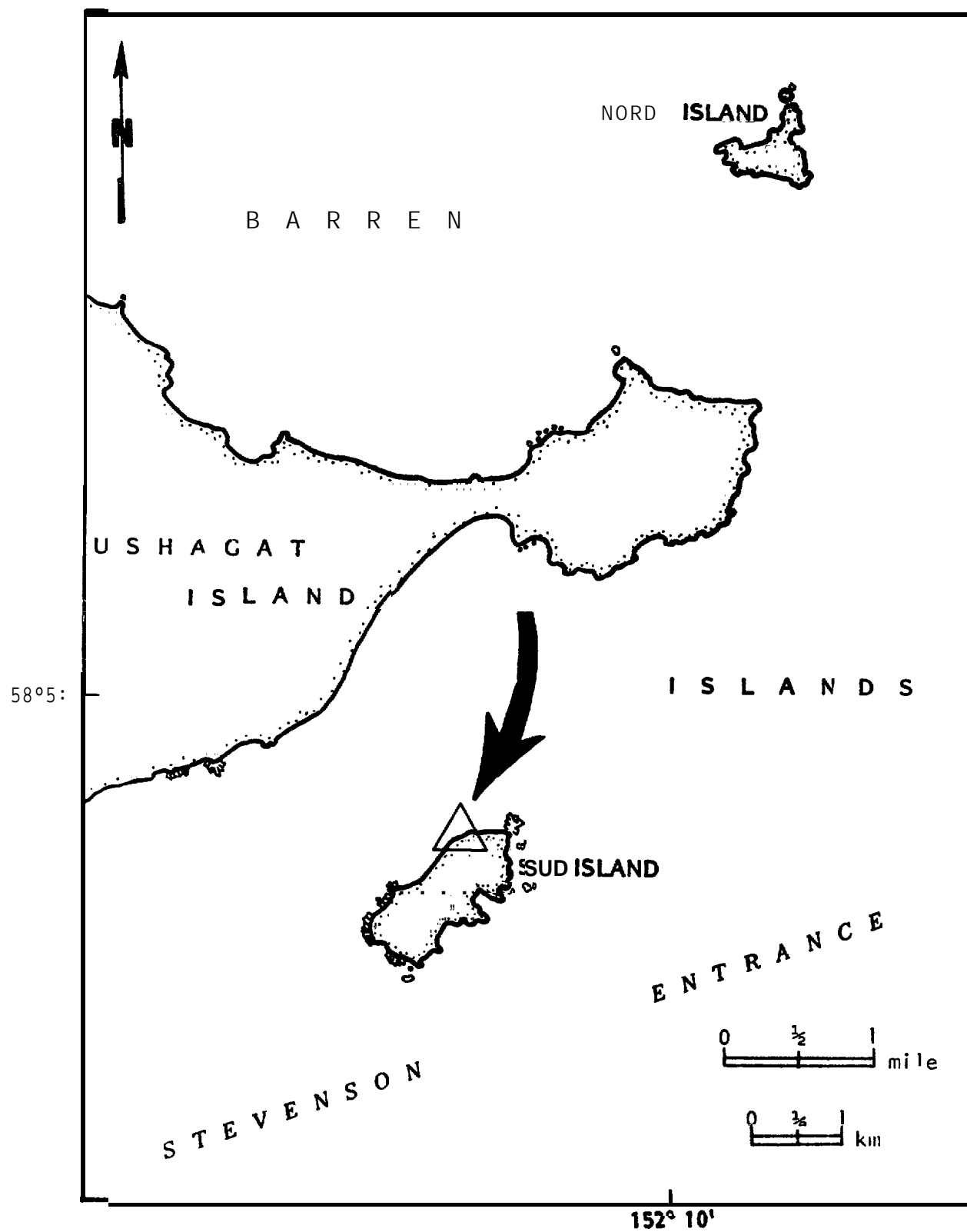


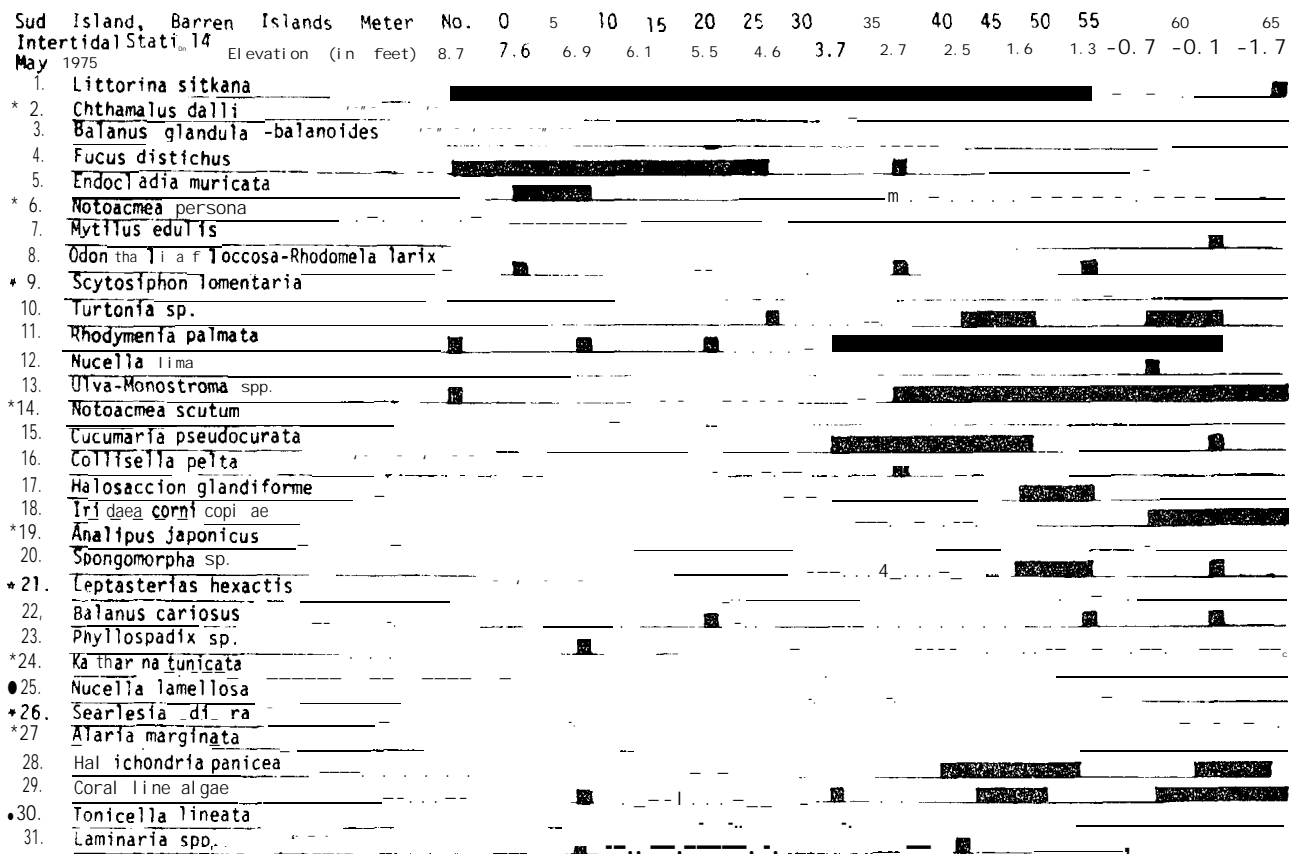
Figure 28. Sud Island site.



Figure 29. Sud Island, Barren Islands. View of transect line with Ushagat Island in background.

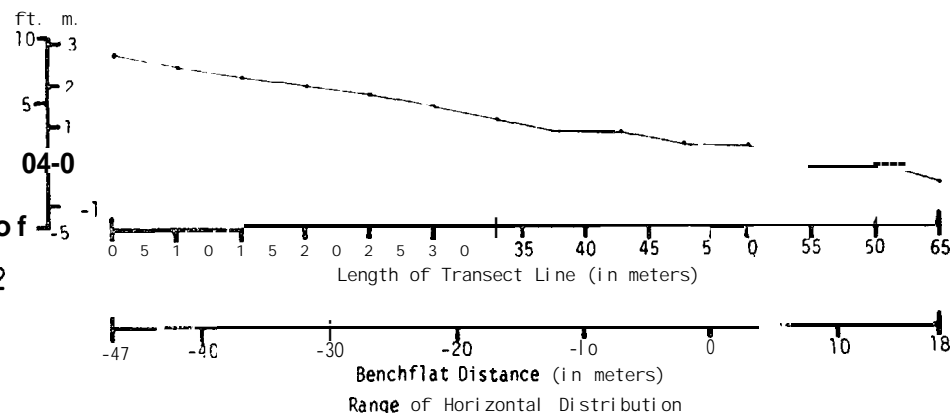


Figure 30. Sud Island, Barren Islands. Lower end of transect line. Note floating kelp offshore.



*Species not present in quadrat
 collections on this transect
 line.

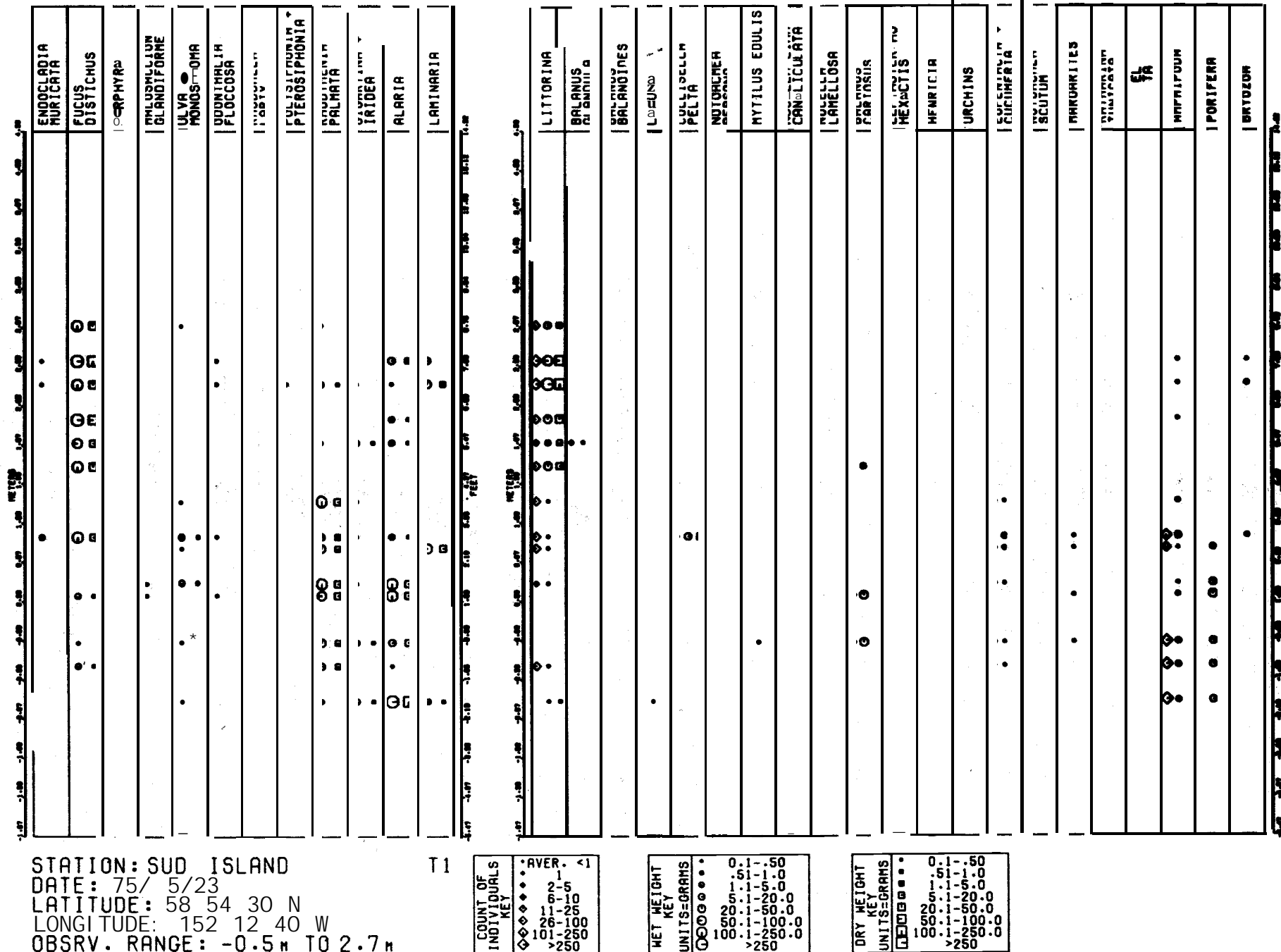
Fig. 31. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m² quadrats along transect line 1.



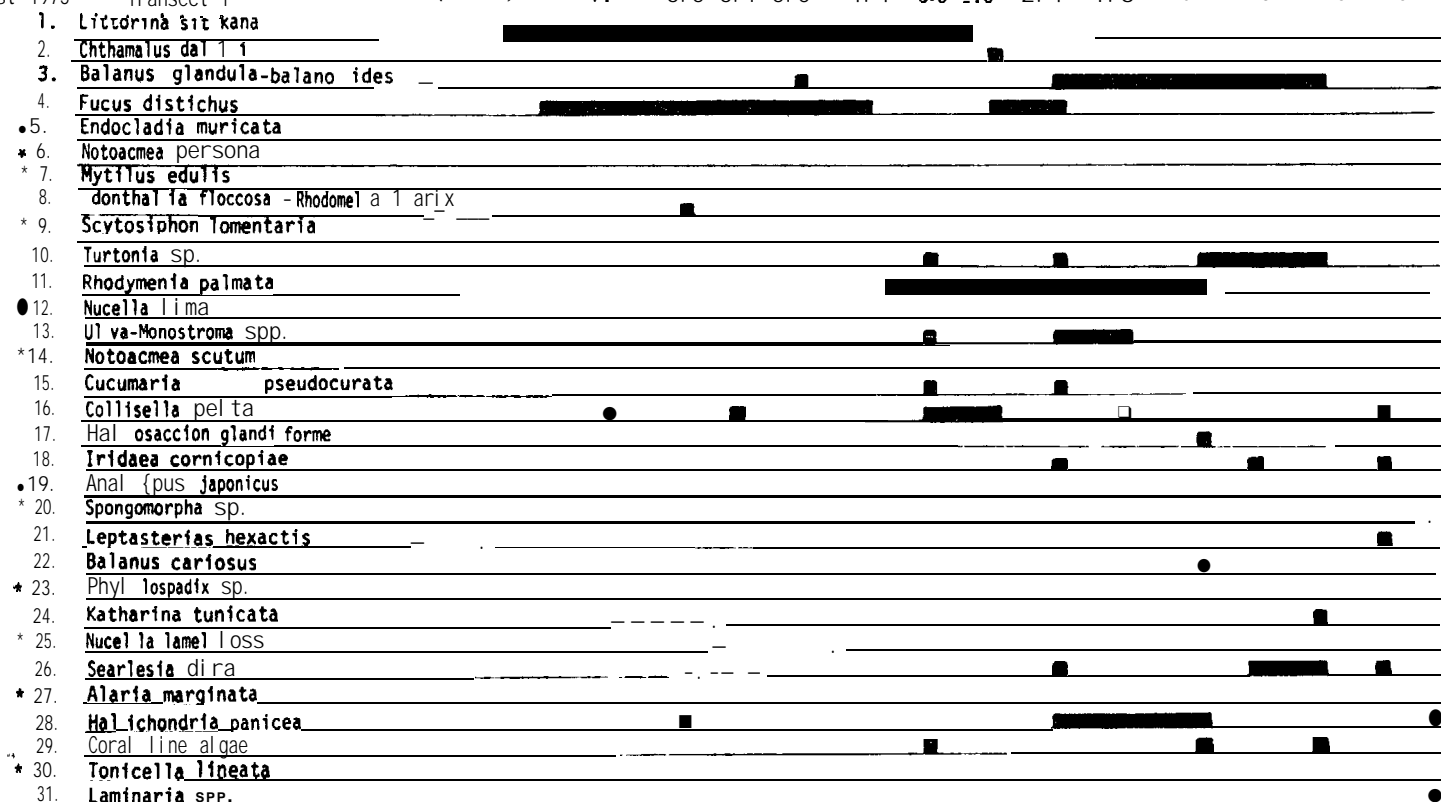
ALGAE

SELECTED INVI R | BI AT | S

2



Sud Island, Barren Islands
 Inter tidal Station 14
 August 1975



* Species not present in quadrat collections on this transect line.

Fig. 33. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m quadrats along transect line 1.

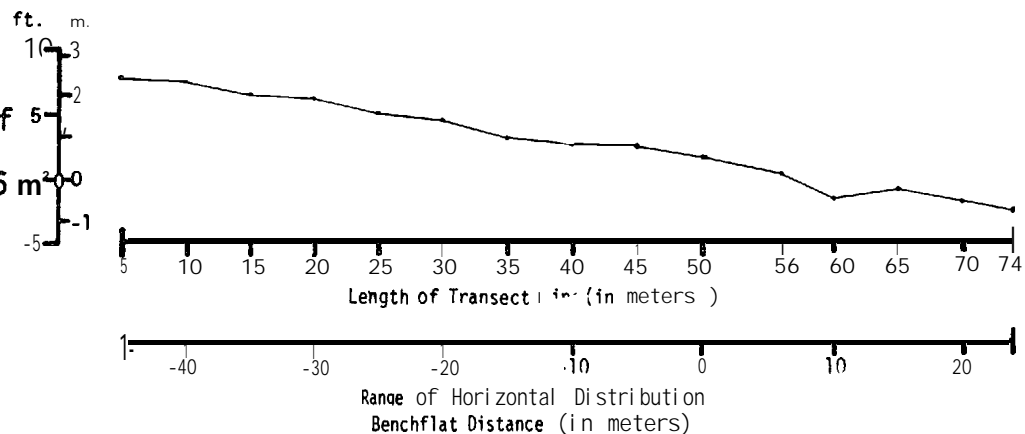
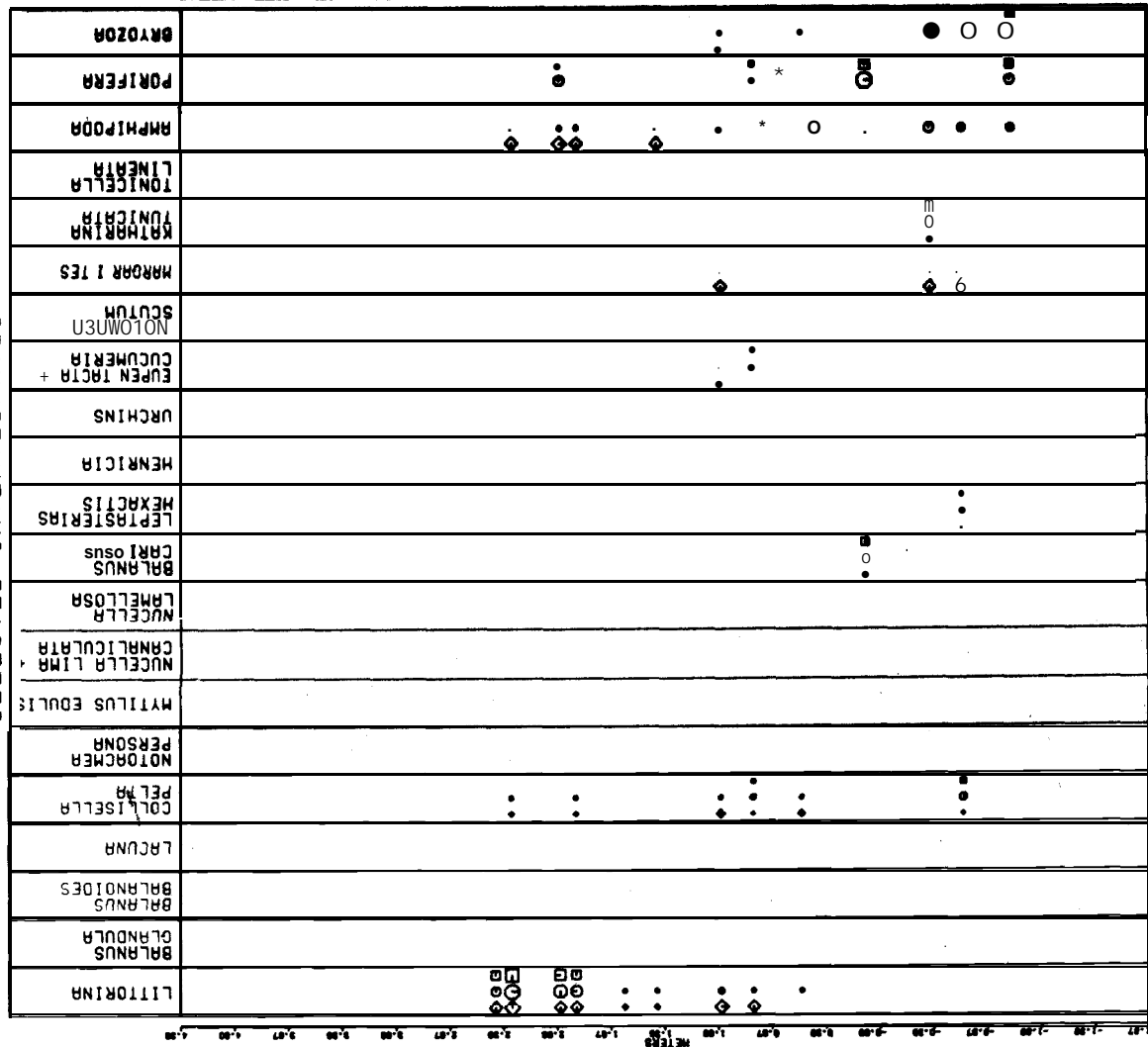


Figure 34. Sud Island, August 1975.
along transect line 1.

SELECTED INVERTEBRATES



INDIVIDUALS COUNT OF KEY	WEIGHT UNITS=GRAMS	WEIGHT UNITS=GRAMS	DRY WEIGHT KEY UNITS=GRAMS	DRY WEIGHT KEY UNITS=GRAMS
100	100	100	100	100
90	90	90	90	90
80	80	80	80	80
70	70	70	70	70
60	60	60	60	60
50	50	50	50	50
40	40	40	40	40
30	30	30	30	30
20	20	20	20	20
10	10	10	10	10
0	0	0	0	0

1 *Littorina sitkana*

Elevation (in feet)

10.8	9.8	9.22	7.7	0	8.4	4.9	5.5	4.3	2.6	7.8	2.5	4.0	-1.4
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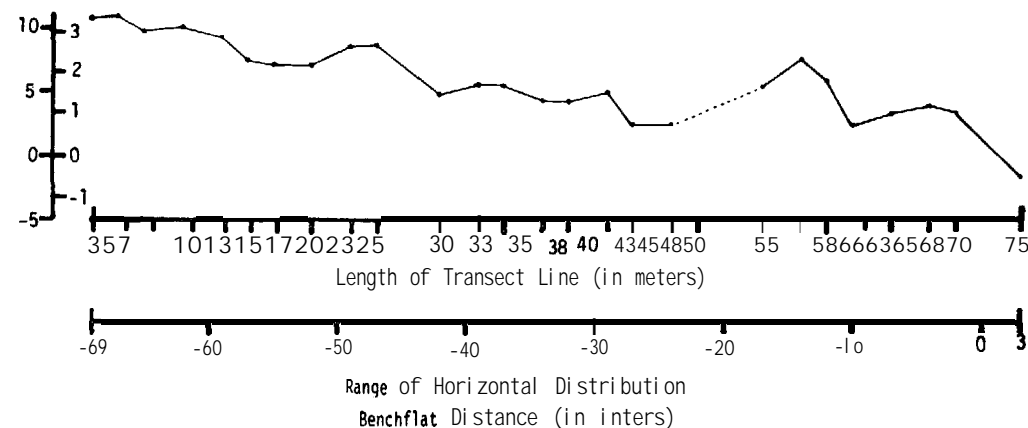
10.9	16.0	7.3	7.0	8.5	5.6	4.4	5.0	2.6	5.6	6.0	3.3	3.7
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collections on this transect
line

[illegible]

vertical distribution of
selected algae and
invertebrates from 1/16 m²
quadrats along transect
line 2.



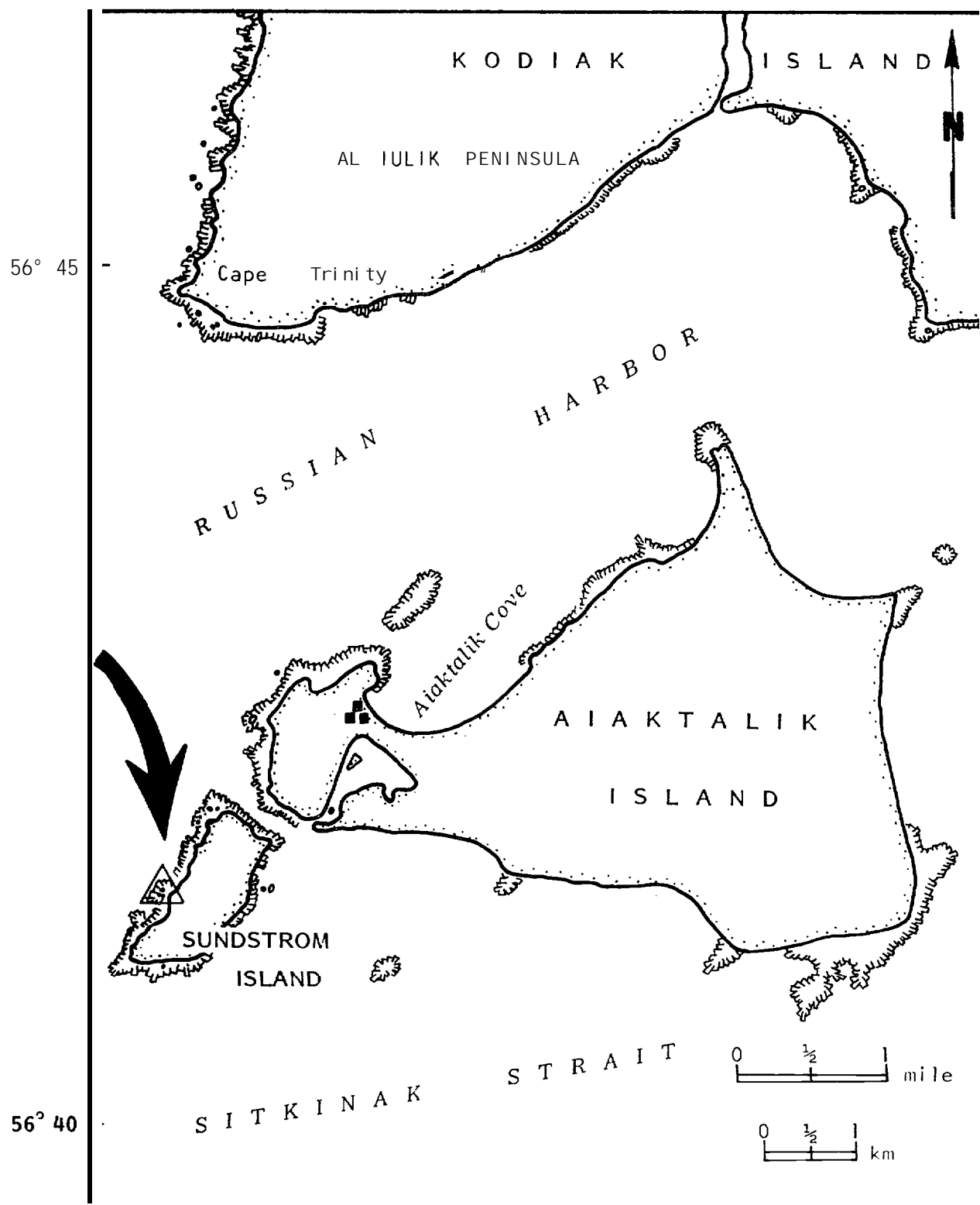


Figure 37, Sundstrom Island site.



Figure 38. Sundstrom Island. Middle of transect line **showing Fucus cover.**



Figure 39. Sundstrom Island. Sampling using arrow sampling method on vertical face. Most visible cover is Alaria.

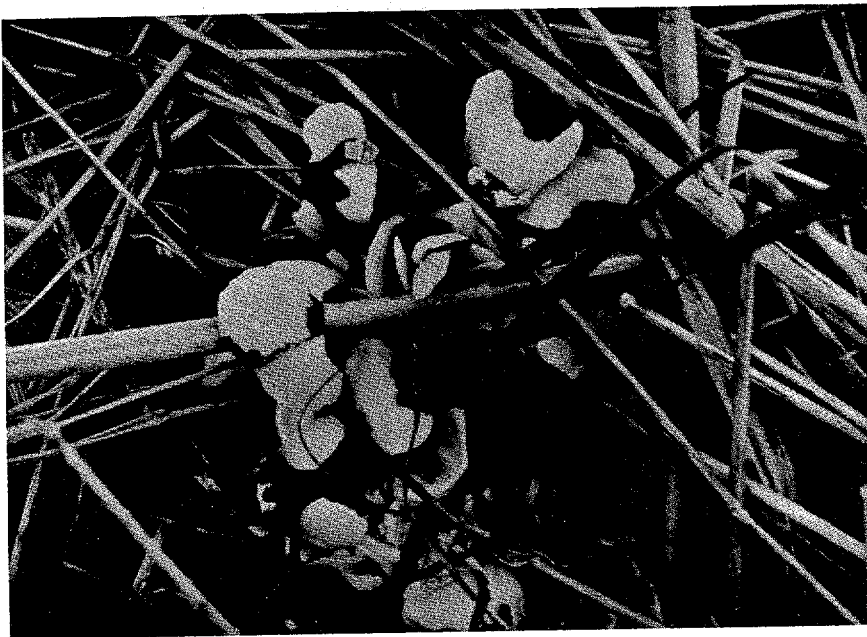


Figure 40. Plates of the chiton *Katharina tunicata* in a gull nesting area on Sundstrom Island.

Sundstrom Island, Trinity Islands Meter No. 0 5 10 11 30 35 37 41 45 50 53 56 60 65 70 75
 Intertidal Station 17 Elevation (in feet) 7.26 2 5.4 6.53 85.5 6.3 5.45 5 2.1 3.3 2.0 0.1 -0.7
 May 1975



* Species not present in quadrat collections on this transect line.

Fig. 41. Horizontal and vertical distribution of selected algae and invertebrates from 1 / 16 m² quadrats along transect line 1.

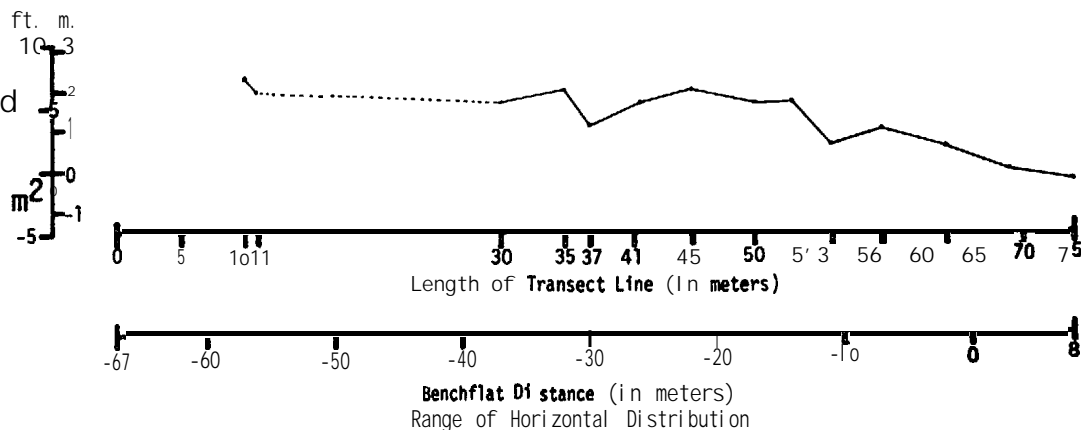
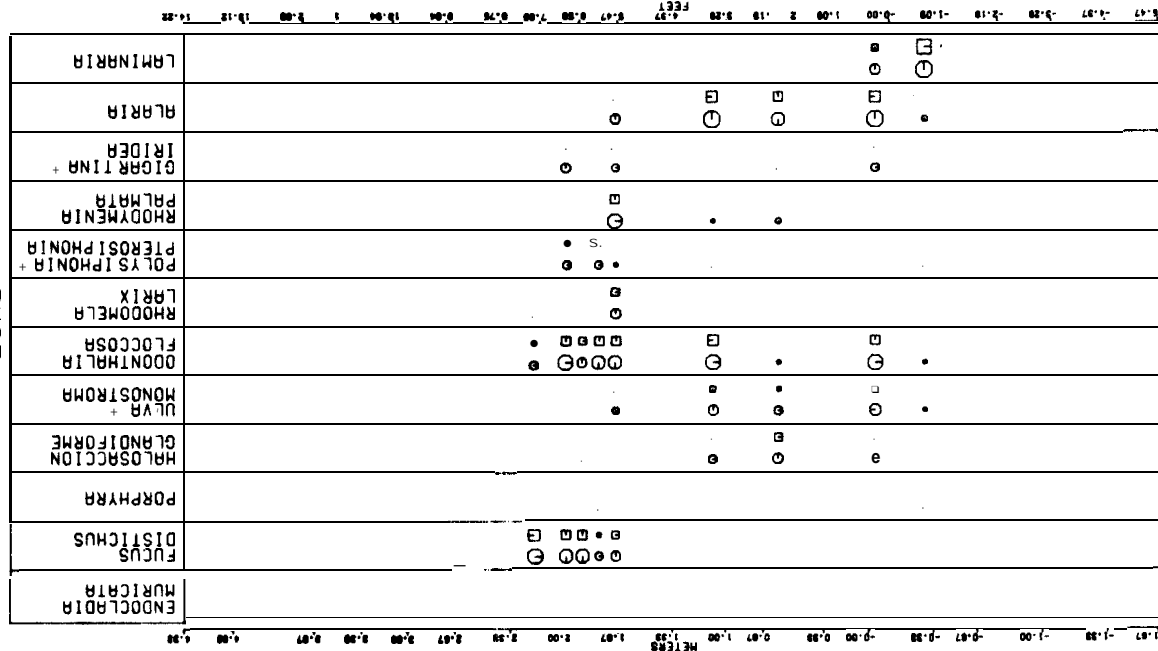


Fig. 42. Sundstrom Island May 1975.

Densities of selected intertidal organisms along transect line 1.

a LGRE

SELECT \approx NVERT \approx RATES



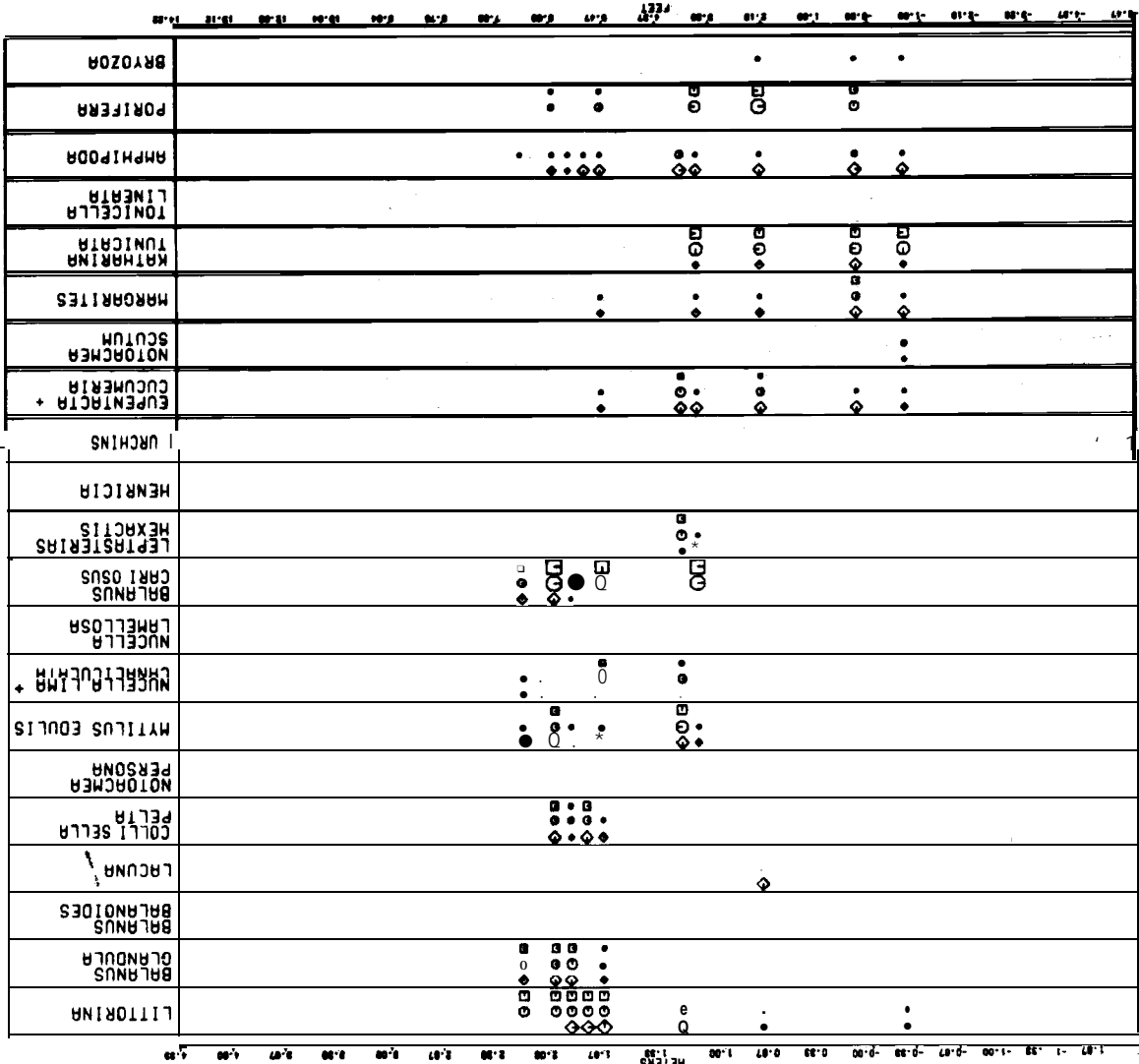
STATION: SUNDBROM SLAND T

DATE: 75/ 5/28

LATITUDE: 56 41 50 N

LONGITUDE: 154 8 60 W

OBSRV. RANGE: -0.2 M TO 2.2 M



• AVER. <1

1

2-5

6-10

11-25

• MET WEIGHT

UNITS=GRAMS

KEY

0.1-1.0

1.1-5.0

• DRY WEIGHT

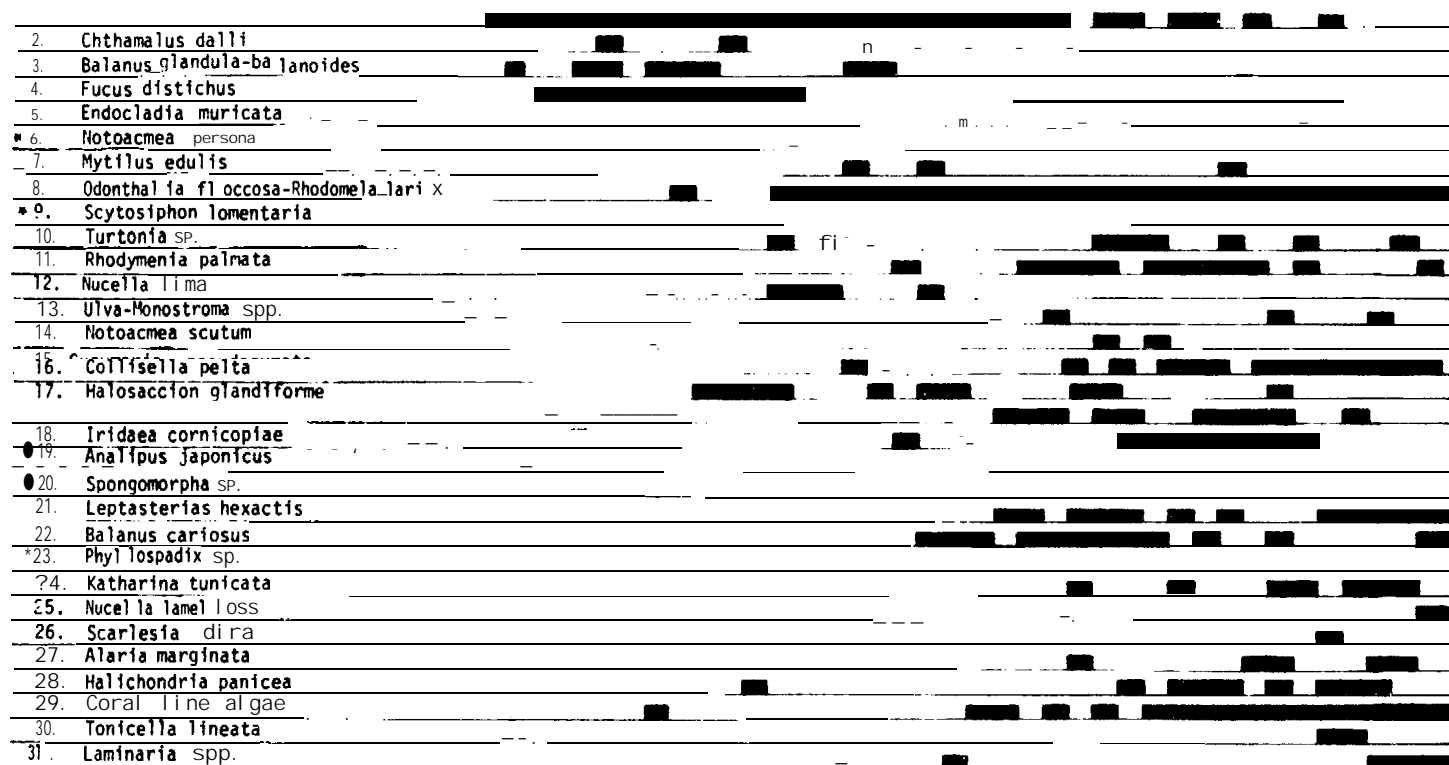
UNITS=GRAMS

KEY

0.1-1.0

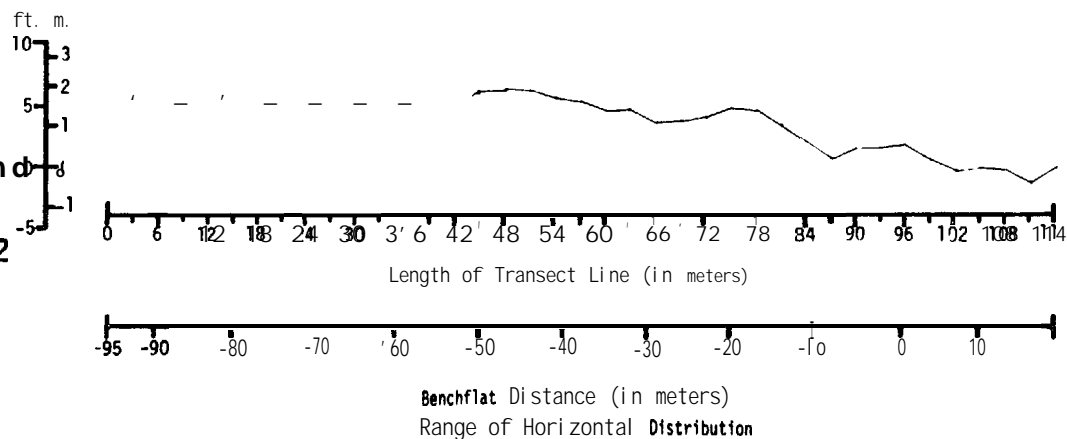
1.1-5.0

Sundstrom Island, Trinity Islands Meter No. 0, 6, 12, 18, 24, 30, 36, 42, 48, 54, 60, 66, 72, 78, 84, 90, 96, 102, 110, 114
 Intertidal Station 17 Elevation (in feet) 10.0 8.7 7.7 6.7 6.0 5.3 4.8 4.9 6.1 5.6 4.6 3.7 4.0 4.6 1.9 1.2 1.4 -0.4 -0.3 -1.0
 August 1975



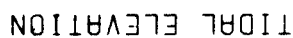
*Species not present in quadrat collections on this transect line.

Fig. 43. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m² quadrats along transect line 1.



Densities of selected intertidal organisms along transect line 1.

SELECTED INTERESTS



STATION: SUNDSTROM ISLAND
DATE: 75/ 8/ 9
LATITUDE: 56 4 50 N
LONGITUDE: 154 6 80 W
OBSRV. RANGE: -0.3 H TO 3.1 H

The lowest zone in our quantitative sampling area was almost entirely covered with long strands of fertile Alaria marginata. The substrate there was basaltic bedrock with deeply cut surge channels, and biota differed between these habitats. Laminaria longipes were often found filling the low channels. In low tidepool areas they were accompanied by Hedophyllum sessile. The area outside the channels and tidepools was characterized by Alaria, Balanus cariosus, and several species of coral line algae, both encrusting and articulated. Several large Katharina tunicata were often seen wedged in among the B. cariosus and were preyed on by sea birds, principally oyster catchers and gulls. Large patches of Halichondria panicea and another sponge also covered much of the low area. There were occasional Henricia leviuscula and Tonicella lineata as well. The red algae were represented by Rhodymenia palmata and Pterosiphonia bipinnata; in addition, Odonthalia sp. were found on the sides of some of the higher channels in the low zone. Spongomorpha spinescens and Monostroma sp. were the green algal species of the low zone. Kelps probably made up over 90% of the algal cover of the low zone.

The middle zone was variable. In general it may be characterized as the red algal belt, for several red algal species were found in their greatest abundance here. Two forms of Rhodymenia (R. palmata and R. palmata f. sarniensis) occurred throughout the zone and intergraded with the low zone as well. Various species of the Odonthalia-Rhodomela group were found along almost the entire length of the transect; the most abundant species was O. floccosa. In the low zone Odonthalia occurred principally on the sides of channels; in the middle zone they were most frequently observed on the bottom of channels or in very shallow areas of standing water. Often the Odonthalia plants were heavily covered with littorine snails. Halosaccion glandiforme were also found in the middle zone; in areas where this species was most abundant, plants of uniform size covered medium-gradient rock surfaces. On rock tops they often intergraded with Fucus distichus. In May 1976 we observed a heavy cover of epiphytic bladed green algae (probably Monostroma) growing on Rhodymenia and Halosaccion.

Balanus cariosus were found in the middle zone as well as in the low zone. In the middle zone they occurred principally in shaded or moist situations under overhangs or at the base of rocks. "The common barnacle in the middle zone was B. glandula which was quite abundant on rock sides and tops. "Groups of limpets were seen on irregularities in the rock surface and Collisella pelts was the common species. Mytilus edulis " " " seldom seen; they occurred only in very small clumps in protected locations.

The three dominant organisms of the high zone were Fucus, Balanus glandula, and Littorina sitkana. Odonthalia were found in areas of standing water. Fucus occurred on rock tops in the middle zone, grew abundantly through most of the high zone, and were found as isolated sprigs where the bedrock graded into pebbles and sand. Balanus glandula were found mixed with B. balanoides throughout the high zone and they both grew above the limit of the Fucus. In the upper part of the zone they grew just below Chthamalus dalli. In several quadrats as many as 25% of the barnacles were dead and only the empty plates remained on the rock. Littorina were found along the entire length of the transect and even beyond. Although their greatest concentrations were on Odonthalia plants, we observed a few Littorina on patches of lichens above the tide line.

We observed condensed vertical zonation on two vertical faces of a huge, high bedrock boulder near the low tide line. One side was exposed to the sea from the southwest while the other side faced the land and was shaded and fairly well protected from waves.

The exposed side was 100% covered with organisms. The base at this side was a flat shelf bared only during the lowest tides. This shelf was covered with a carpet of large B. cariosus which in turn was covered with several varieties of coralline algae, some of which were bleached at the edges. Alaria plants were found wherever there was room for their holdfasts to attach. The lowest zone of the vertical portion of the exposed face had a cover of B. cariosus, Alaria sp., Rhodomenia, and Odonthalia. The Odonthalia often completely covered the barnacles with a short, tuft-like form. The next higher zone was covered with Rhodomenia, Halosaccion, Fucus, and B. glandula. Both the Fucus and Halosaccion grew just below the summit of the boulder. Sundstrom Island has a large population of sea birds and the top of the boulder was crowned with a luxuriant growth of Prasiola meridionalis, an alga which is usually found only in areas of high guano concentration.

The landward, protected side of the boulder had a very patchy distribution of organisms; everything grew in clumps with bare rock in between. The lowest zone had patches of Alaria sp. and B. cariosus. Odonthalia grew between and above this zone. The next zone was composed of clumps of Fucus and Mytilus. In an area where the rock formed a ridge and flattened out a little before the next vertical rise, the Mytilus had a more continuous distribution and formed a narrow band. The zone below the summit had a patchy distribution of B. glandula and Fucus.

Cape Kaguyak (Kodiak Island)

Cape Kaguyak is near the southern tip of Kodiak Island. Our sampling site, which lies slightly inside Cape Kaguyak on the north side, is partially protected from the full force of oceanic turbulence (Figure 45). We sampled in May 1976.

The beach is somewhat irregular, grading from large boulders near the point to gravel part of the way inside Kaguyak Bay. The large boulder area which is only a short distance from our site appears to be influenced by wave force from the open ocean side. Storm surf in this area appears able to roll across the land into Kaguyak Bay. The large boulders appear to have been shifted about recently, and several large tide pools at the highest elevations indicate that waves from the Pacific side inundate the area with spray.

The upper part of our sampling site was composed of sand, gravel, and small boulders which graded into larger boulders nearer the water. The beach had a moderate and fairly regular slope generally unbroken by large boulders or bedrock hummocks.

Two parallel transect lines were used at Cape Kaguyak during May 1976. Both were used to enumerate algal and invertebrate cover and also to make 15 quantitative collections. The transects ran through an area of small to medium boulders (Figures 46 and 47). Distribution of algae and invertebrates was patchy (Figures 48-51) as a result of physical battering of the boulders by surf during storms. The upper end of transect 1, or 32% of the transect,

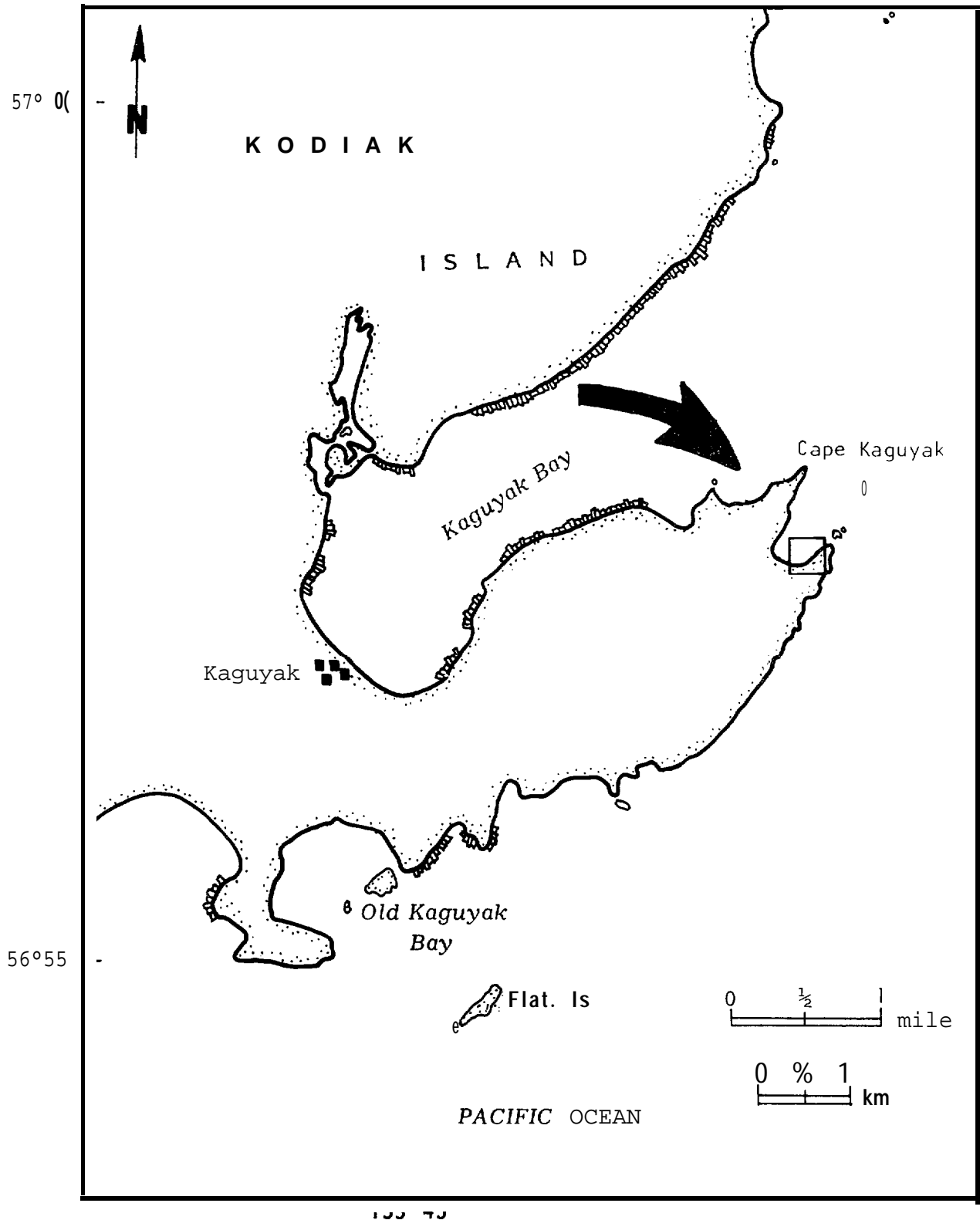


Figure 45. Cape Kaguyak site.

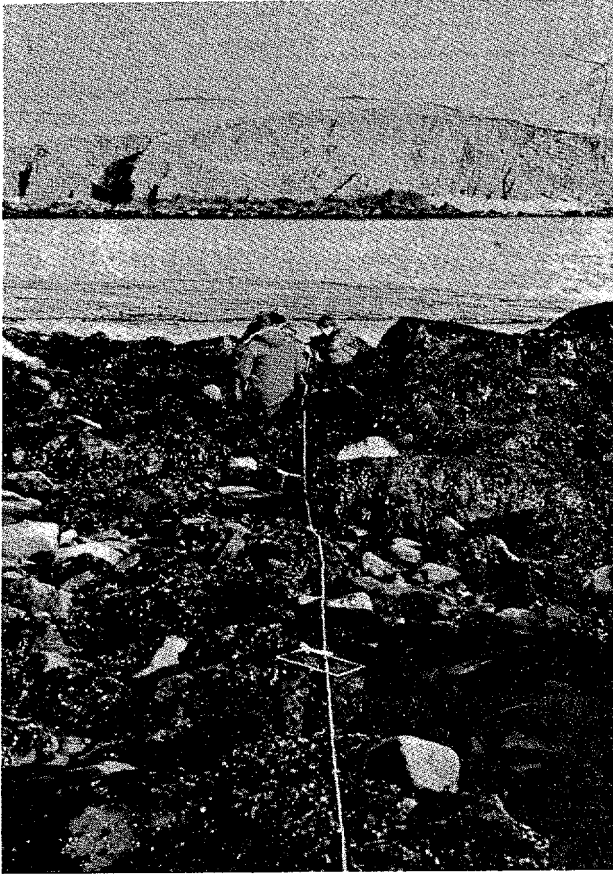
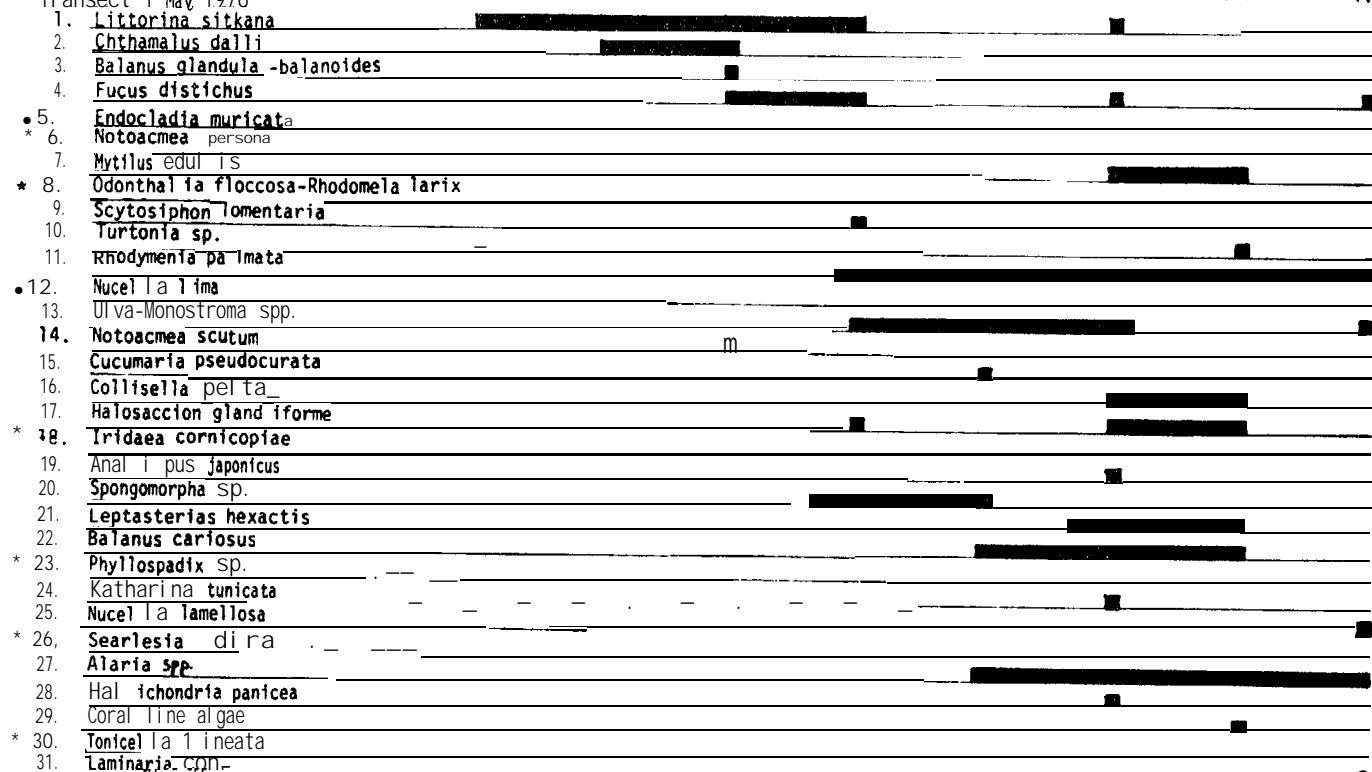


Figure 46. Cape Kaguyak.
View of transect line.



Figure 47. Cape Kaguyak. View of transect lines. Sampling area showing transect lines 1 and 2.

Cape Kaguyak, Kodiak Island Meter No. 0 5 10 15 20 25 30 35
 Intertidal Station 36 Elevation (in feet) 9.8 4.1 4.1 3.9 1.8 1.3 0.4 -1.3
 Transect 1 May 1976



* Species not present in quadrat collections on this transect line.

ft. m.
 10 3
 5 2
 0 1
 -5 0
 -1

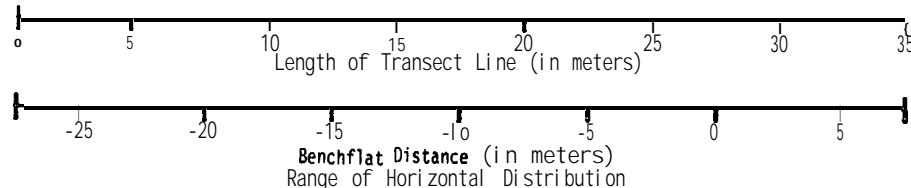


Fig. 48. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m² quadrats along transect line 1.

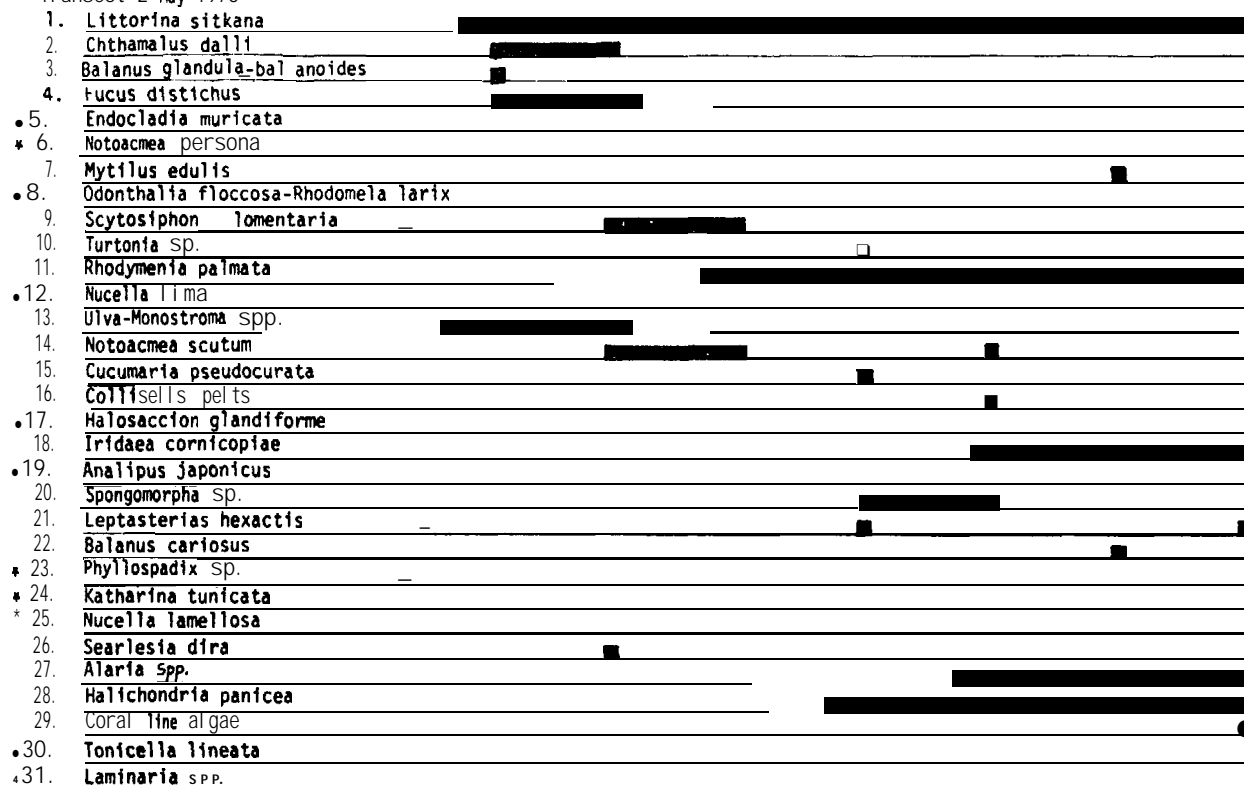
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SELECTED INVERTEBRATES

[illegible]

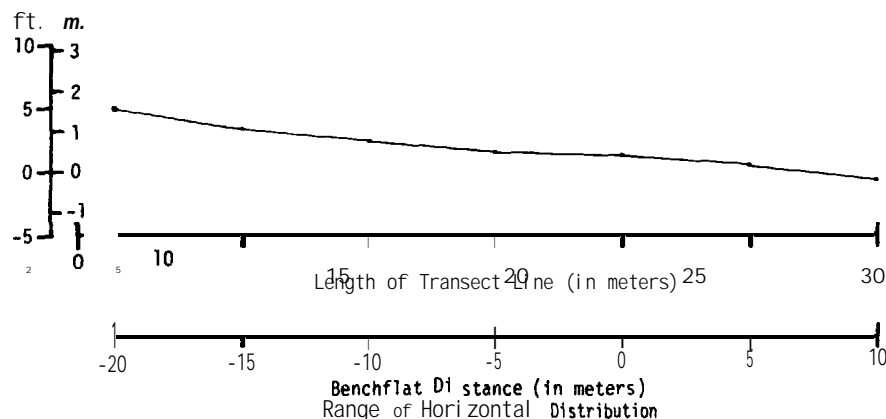
89

Cape Kaguyak
 Intertidal Station 36 Elevation (in feet) 5.0 3.3 2.5 1.7 1.2 0.6 -0.8
 Transect 2 May 1976



• Species not present in quadrat collections on this transect line.

Fig. 50. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m quadrats along transect line 2.



31



lacked algal cover. In the remaining quadrats, Alaria and Rhodymenia were spatially dominant. The spatial dominance of Rhodymenia is not reflected in Figure 49, as R. palmata f. sarniensis was not read as R. palmata by the computer. Distribution of algae along transect 2 was somewhat less variable; all of the quadrats had some algal cover. Fucus and Porphyra were spatially dominant along the upper end of the transect and Alaria and Rhodymenia were spatially dominant along the lower end. Bladed green algae were found at all levels along transect 2.

Invertebrate populations were small. Mussels, predatory molluscs, and sea stars were uncommon. The upper area of the beach was characterized by Littorina sitkana, Chthamalus dalli, Balanus glandula, Notoacmea scutum, and Collisella digitalis. Lower levels were characterized by B. cariosus, several species of gastropod (e. g., Margarita helicinus, Lacuna marmorata), Halichondria panicea, bryozoa, and serpulid worms (Spirorbis). Most of the non-colonial forms were small in size and, except for sponges, the biomass of invertebrates was generally small along both lines.

Three Saints Bay (Kodiak Island)

Three Saints Bay is on southeast Kodiak Island about 30 mi north of Cape Trinity. The area we sampled in May 1975, Cape Liakik, is at the entrance of Three Saints Bay and is directly exposed to wave action from the Gulf of Alaska from the south-southeast (Figure 52). Areas exposed to the west, north, and east are semi-protected. Cape Liakik is basaltic bedrock with steep cliffs, spires, and a low bedrock outcrop. We ran our transect line across the low bedrock area (Figures 53 and 54). The lowest part of the transect ran across an area cut with deep surge channels. Above this zone was an area of low-relief ridges and valleys of gradually-increasing gradient which merged into steep rock cliffs at the head of the transect. Nybakken (1969) sampled Three Saints Bay extensively in 1963, before the Alaskan earthquake in 1964, and provided species lists for a number of sites in the bay.

Some species which occurred in fair abundance are not represented in our transect line collections. For instance, a bed of the kelp Nereocystis luetkeana could be seen floating in the offshore area beyond the Cape Liakik. High bedrock outcrops near the low tide line also occurred outside the area of the transect. "

The lowest area of the transect began at the low tide line and had a dense cover of Alaria, principally A. marginata (Figures 55 and 56). Much of the Alaria was short, with eroded blades, with or without sporophylls. A heavy layer of Balanus cariosus grew on the bedrock with the Alaria holdfasts growing on or between them. The B. cariosus were large, often chimney-form, with heavy walls. When we pried clumps of B. cariosus from the rock, we found many small organisms sheltered between the large barnacles. These included the starfish Leptasterias hexactis, small gastropod, various polychaete worms, and the ubiquitous amphipods and isopods.

Other conspicuous organisms in the low zone along the transect line were the chitons Katharina tunicata and Tonicella lineata. K. tunicata were more abundant, with as many as eight per 1/16 m² quadrat. A patchy cover of

sponge, mostly Halichondria panicea, was extensive. Various species of coral line algae, both encrusting and articulated, were also seen throughout this zone.

The spatially dominant animal in the middle intertidal zone was Mytilus, although barnacles were also abundant. A narrow area between the Alaria and Mytilus zones had a patchy distribution of barnacles, mostly medium to large B. cariosus with a few B. glandula. Large Mytilus formed only a narrow band on the rock tops near the ~~lower~~ boundary ~~of the~~ distribution on the transect, becoming, higher up on the transect, an almost solid band about a meter wide. The algae Porphyra sp. and Spongomorpha spinescens were often seen growing on the Mytilus band.

The high zone was characterized by a heavy cover of Fucus distichus. The lower end of the Fucus zone was characterized by M. edulis, small B. cariosus, and short, profusely-branched, fertile Fucus plants. The B. cariosus became interspersed with and were gradually replaced by B. glandula. Higher on the beach some Mytilus occurred through most of the zone but in the very highest area only littorines were found with small B. glandula and short, sterile Fucus growing in *crevices*. Patches of Odonthalia floccosa and Endocladia muricata were also common throughout the Fucus area.

A second, more protected site, was sampled farther inside Three Saints Bay in August 1975 (Figure 52). The lower end of the transect ran through an area of hummocky bedrock with tidepools. Alaria, Balanus cariosus, and Katharina tunicata were characteristic of the lower tidal zone, although less abundant than at Cape Liakik (Figures 57 and 58). Encrusting coralline algae and the small chiton Tonicella lineata, both found in the low zone, were more abundant than at Cape Liakik. The upper end of the transect graded into shale bedrock heavily covered with the barnacles Balanus glandula and Chthamalus dalli as well as littorine snails. Mytilus edulis were abundant in this high zone and also on the tops of bedrock hummocks in the low zone. The branched red algae Odonthalia floccosa and Rhodomela larix, uncommon at Cape Liakik, were abundant at the second site.

Lagoon Point (Sitkalidak Island)

Three transect lines were laid in the vicinity of Lagoon Point on Sitkalidak Island, Sitkalidak Straits, in May 1976 (Figures 59-62). Transect 1 was laid near Lagoon Point on a shore of moderate slope covered with large boulders. Transects 2 and 3 were approximately 100 and 200 m west of transect 1, in areas of progressively smaller boulders.

Algal cover was heaviest in the lowest zone of transect 1 (Figures 63 and 64). Alaria were most abundant in estimations of percent cover and also in terms of wet weight in quadrat collections. Laminaria were abundant in the lowest zone and continued seaward subtidally. Coralline algae, encrusting and articulated, were also abundant in the low zone. Encrusting coral lines are not shown in the density figures because we did not collect them. Rhodomenia, Fucus, and Odonthalia were spatially dominant higher along the transect, although not as abundant as species of the low tide zone. Balanus cariosus, Mytilus edulis, and numerous gastropod are included among the dominant (ranked by wet weight) organisms in the samples. Populations of invertebrates seemed especially rich in this area but the data do not always

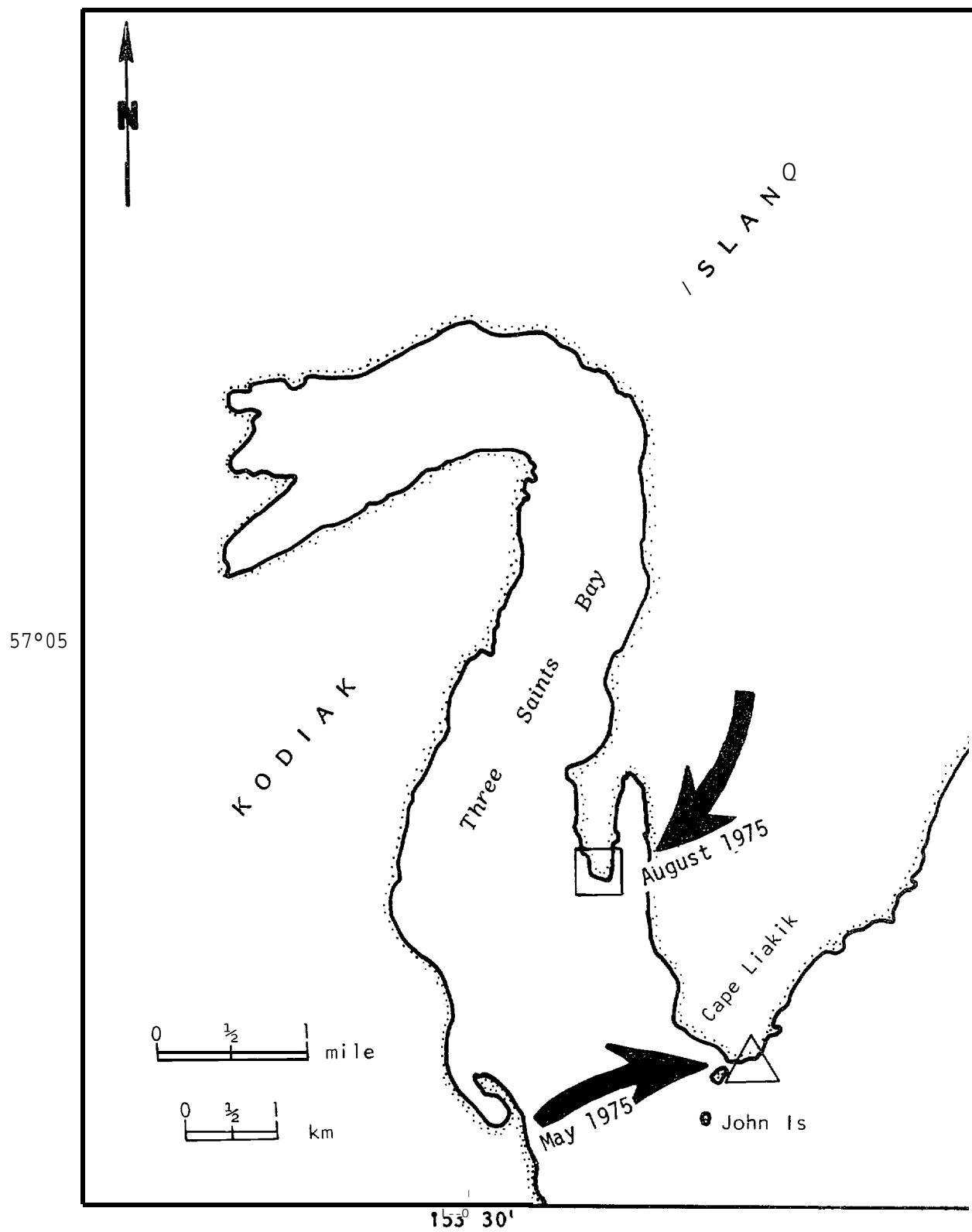


Figure 52. Three Saints Bay sites.

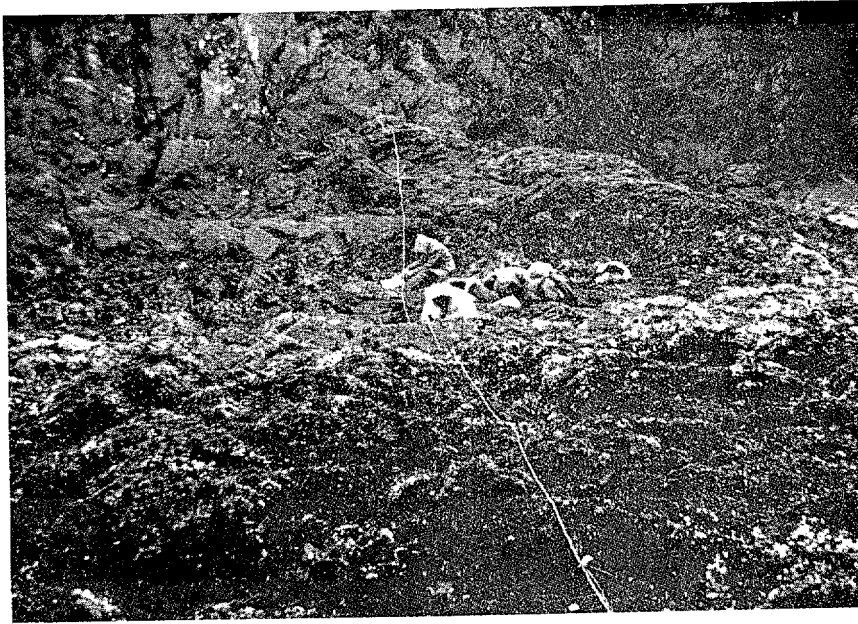


Figure 53. Three Saints Bay, May 1975. Upper end of transect line showing Mytilus, **barnacle** and Fucus cover.

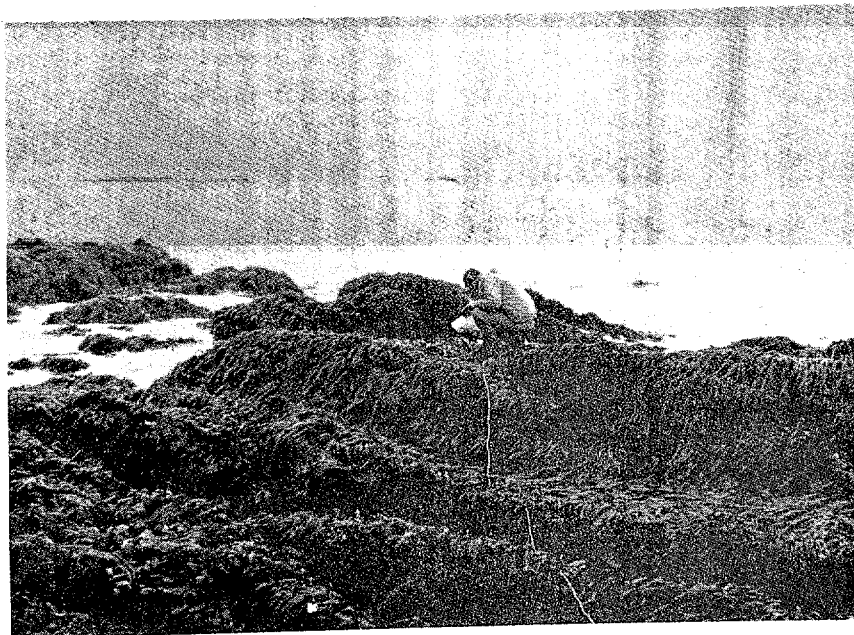
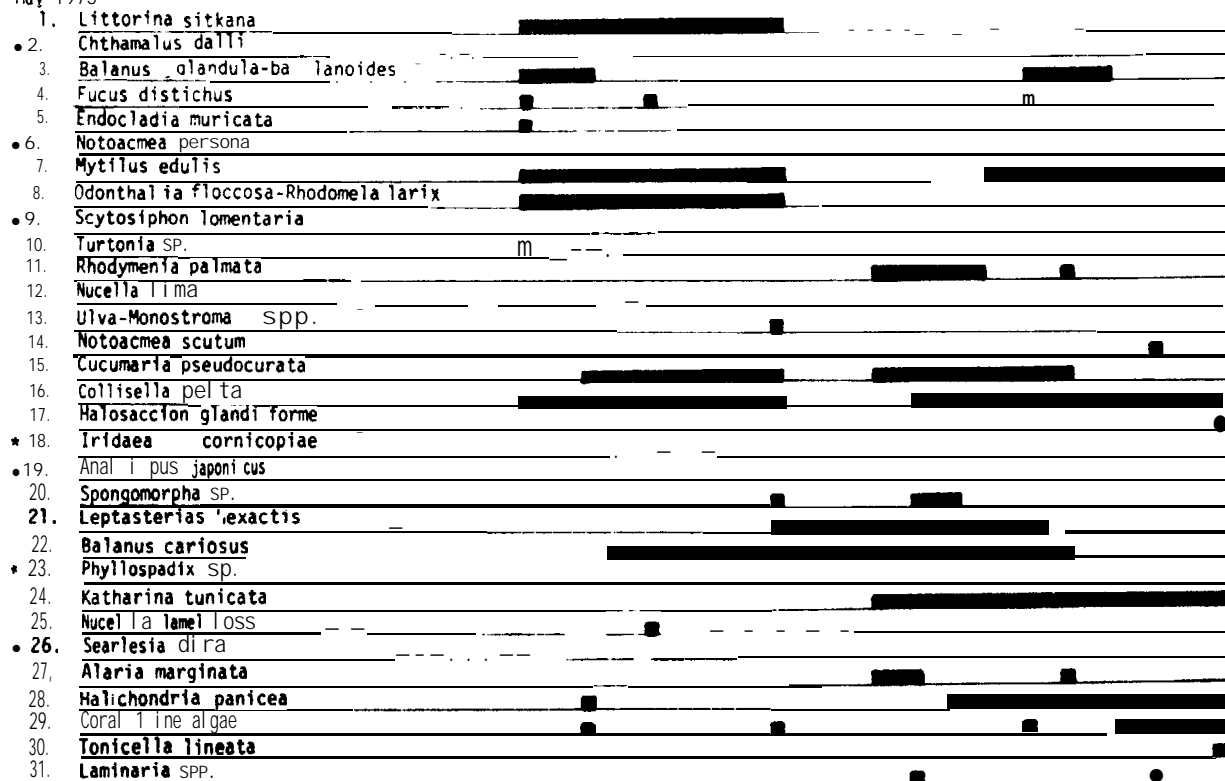


Figure 54. Three Saints Bay, May 1975. Lower end of transect line showing heavy Alaria cover.

Three Saints Bay
 Intertidal Station 16
 May 1975

Meter	No.	5	10	15	25	33	36	39	41	45	48	51	55	60
Elevation (in feet)		5.1	3.4	3.8	3.4	0.01	.91	.61	.4	1.82	.2	1.9	0.6	2.1



• Species not present in quadrat collections on this transect line.

Fig. 55. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m² quadrats along transect line 1.

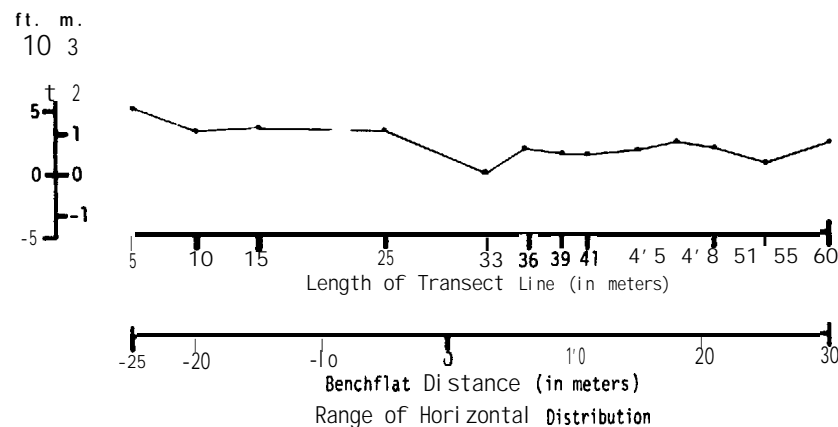
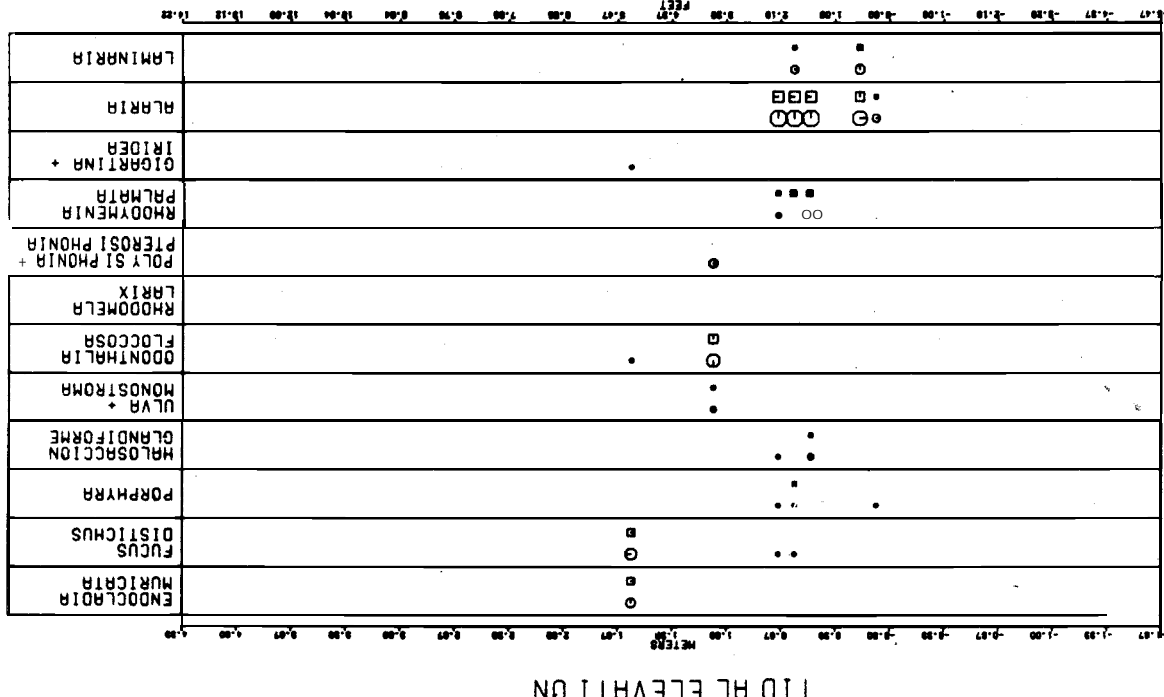


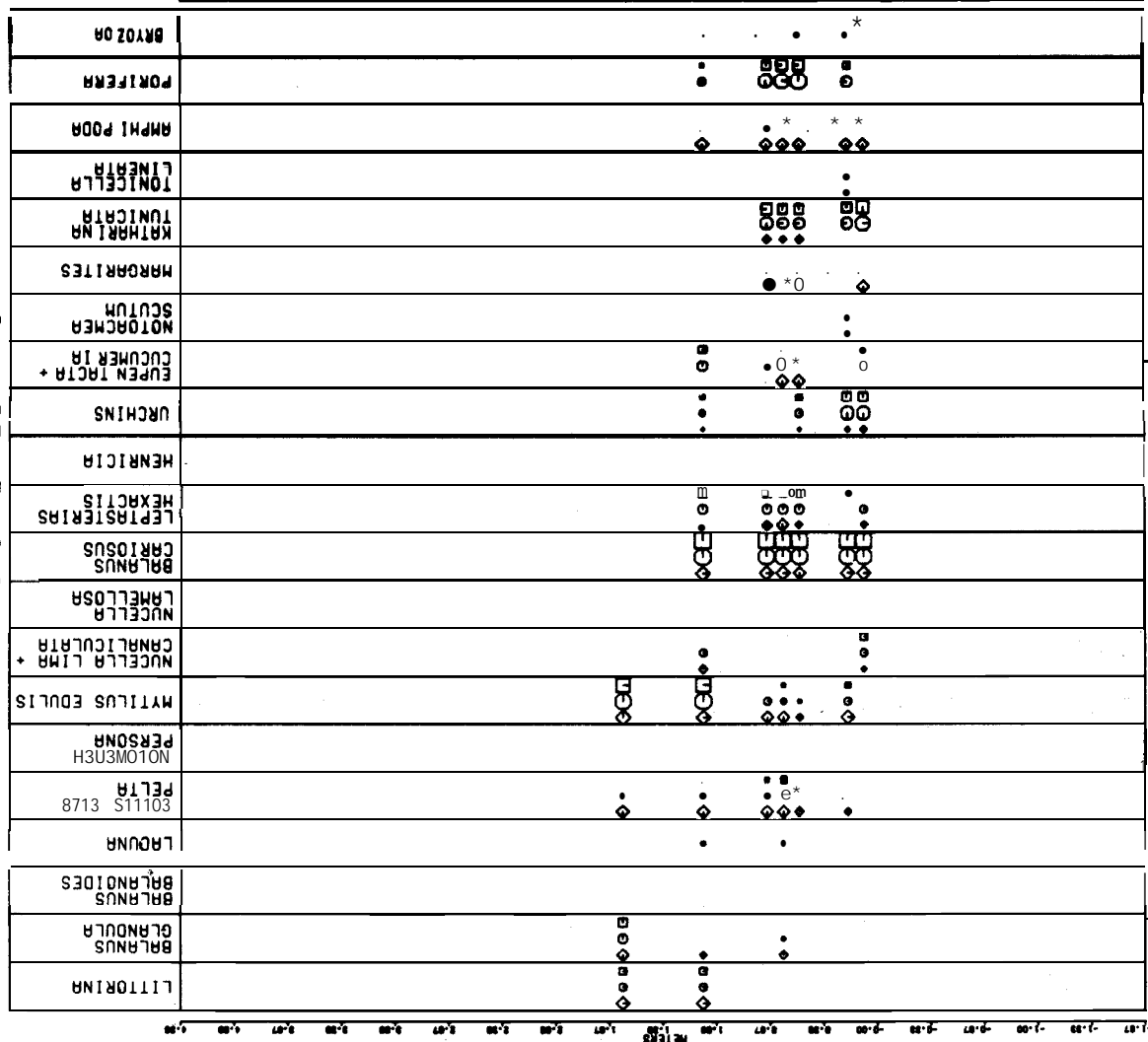
Fig. 56. Three Saints Bay, May 1975. Densities of selected intertidal organisms along transect line 1.

ALGAE



STATION: THREE SAINTS BAY
 DATE: 75-5/29
 LATITUDE: 57° 7' 80" N
 LONGITUDE: 152° 28' 70" W
 OBSRV. RANGE: 0.1 m TO 1.6 m

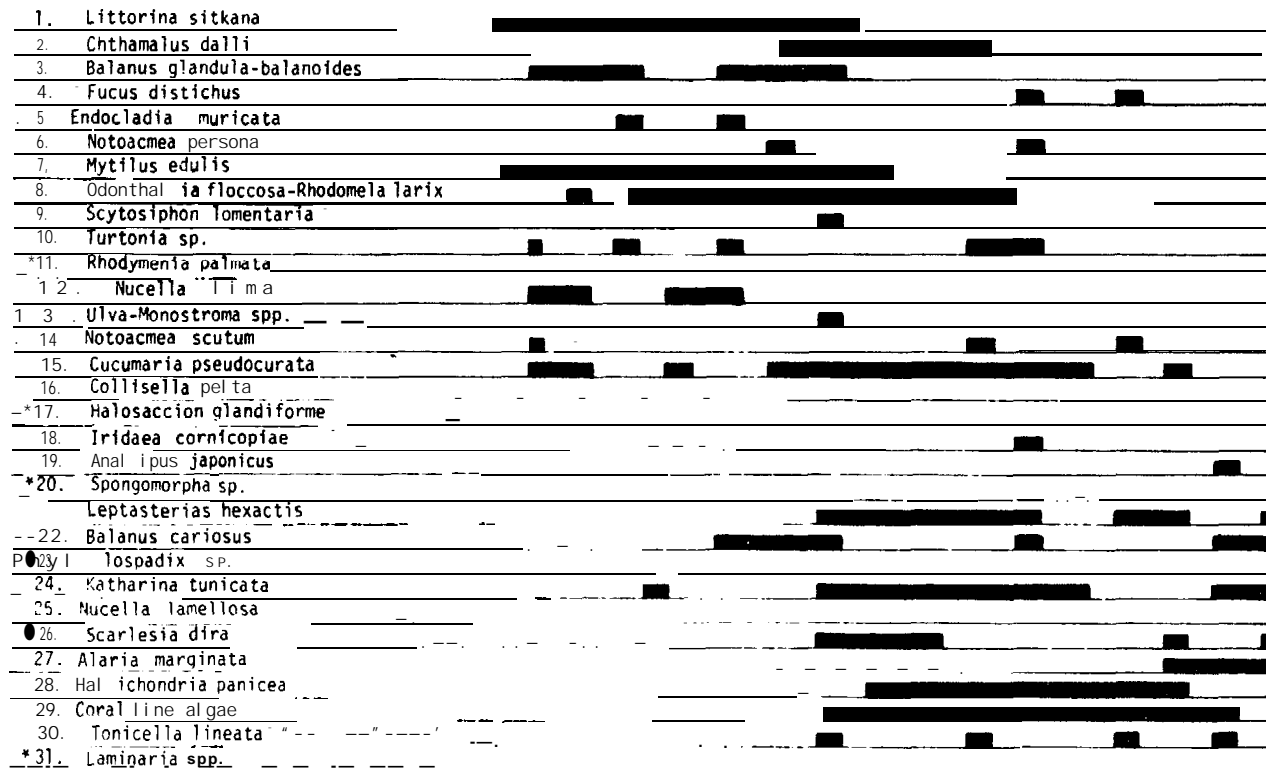
SELECTED INVERTEBRATES



STATION: THREE SAINTS BAY
 DATE: 75-5/29
 LATITUDE: 57° 7' 80" N
 LONGITUDE: 152° 28' 70" W
 OBSRV. RANGE: 0.1 m TO 1.6 m

Three Saints Bay
Intertidal Station 16
August 1975

Meter No. 45 42 39 36 33 30 27 24 21 18 15 12 9 6 3 0
Elevation (in feet) 4.9 4.4 4.0 3.4 5.6 4.5 2.3 1.5 1.6 0.7 0.1 -0.7 -0.7 -0.8 0.1



• Species not present in quadrat collections on this transect line.

Fig. 57. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m² quadrats along transect line 1.

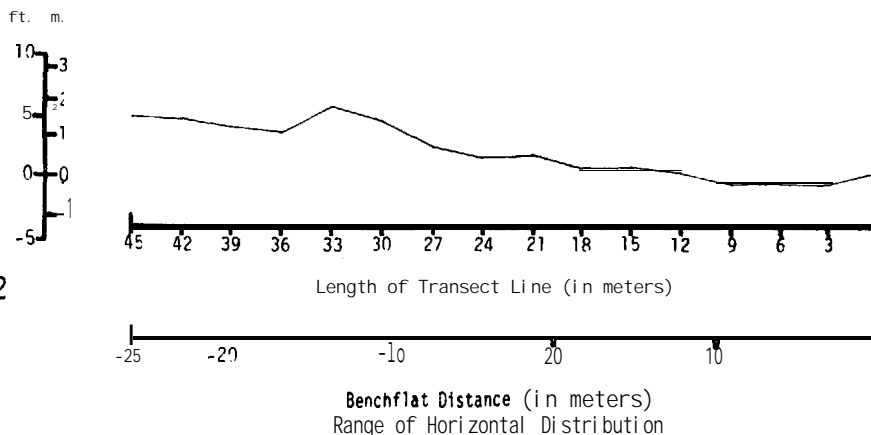
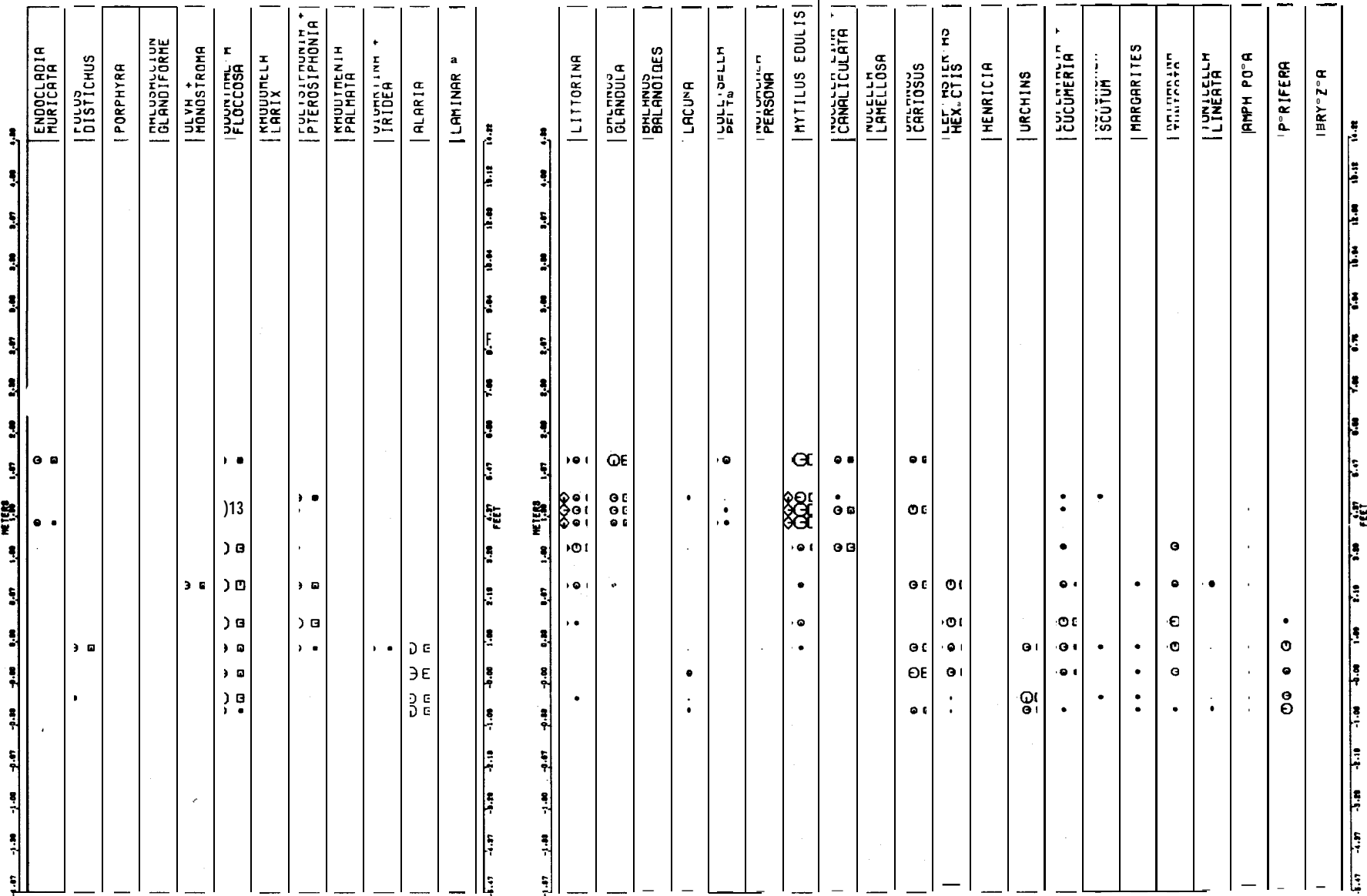


Fig. 58. Three Saints Bay, August 1975. Densities of selected intertidal organisms along transect line 1.

TIDAL ELEVATION



STATION: THREE SAINTS BAY T1
 DATE: 75/ 8/ 7
 LATITUDE: 57 7 80 N
 LONGITUDE: 152 28 70 N
 OBSRV. RANGE: -0.211 TO 1.8 M

COUNT OF INDIVIDUALS KEY
 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000 1001 1002 1003 1004 1005 1006 1007 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017 1018 1019 1020 1021 1022 1023 1024 1025 1026 1027 1028 1029 1030 1031 1032 1033 1034 1035 1036 1037 1038 1039 1040 1041 1042 1043 1044 1045 1046 1047 1048 1049 1050 1051 1052 1053 1054 1055 1056 1057 1058 1059 1060 1061 1062 1063 1064 1065 1066 1067 1068 1069 1070 1071 1072 1073 1074 1075 1076 1077 1078 1079 1080 1081 1082 1083 1084 1085 1086 1087 1088 1089 1090 1091 1092 1093 1094 1095 1096 1097 1098 1099 1100 1101 1102 1103 1104 1105 1106 1107 1108 1109 1110 1111 1112 1113 1114 1115 1116 1117 1118 1119 1120 1121 1122 1123 1124 1125 1126 1127 1128 1129 1130 1131 1132 1133 1134 1135 1136 1137 1138 1139 1140 1141 1142 1143 1144 1145 1146 1147 1148 1149 1150 1151 1152 1153 1154 1155 1156 1157 1158 1159 1160 1161 1162 1163 1164 1165 1166 1167 1168 1169 1170 1171 1172 1173 1174 1175 1176 1177 1178 1179 1180 1181 1182 1183 1184 1185 1186 1187 1188 1189 1190 1191 1192 1193 1194 1195 1196 1197 1198 1199 1200 1201 1202 1203 1204 1205 1206 1207 1208 1209 1210 1211 1212 1213 1214 1215 1216 1217 1218 1219 1220 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1821 1822 1823 1824 1825 1826 1827 1828 1829 1830 1831 1832 1833 1834 1835 1836 1837 1838 1839 1840 1841 1842 1843 1844 1845 1846 1847 1848 1849 1850 1851 1852 1853 1854 1855 1856 1857 1858 1859 1860 1861 1862 1863 1864 1865 1866 1867 1868 1869 1870 1871 1872 1873 1874 1875 1876 1877 1878 1879 1880 1881 1882 1883 1884 1885 1886 1887 1888 1889 1890 1891 1892 1893 1894 1895 1896 1897 1898 1899 1900 1901 1902 1903 1904 1905 1906 1907 1908 1909 1910 1911 1912 1913 1914 1915 1916 1917 1918 1919 1920 1921 1922 1923 1924 1925 1926 1927 1928 1929 1930 1931 1932 1933 1934 1935 1936 1937 1938 1939 1940 1941 1942 1943 1944 1945 1946 1947 1948 1949 1950 1951 1952 1953 1954 1955 1956 1957 1958 1959 1960 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040 2041 2042 2043 2044 2045 2046 2047 2048 2049 2050 2051 2052 2053 2054 2055 2056 2057 2058 2059 2060 2061 2062 2063 2064 2065 2066 2067 2068 2069 2070 2071 2072 2073 2074 2075 2076 2077 2078 2079 2080 2081 2082 2083 2084 2085 2086 2087 2088 2089 2090 2091 2092 2093 2094 2095 2096 2097 2098 2099 2100 2101 2102 2103 2104 2105 2106 2107 2108 2109 2110 2111 2112 2113 2114 2115 2116 2117 2118 2119 2120 2121 2122 2123 2124 2125 2126 2127 2128 2129 2130 2131 2132 2133 2134 2135 2136 2137 2138 2139 2140 2141 2142 2143 2144 2145 2146 2147 2148 2149 2150 2151 2152 2153 2154 2155 2156 2157 2158 2159 2160 2161 2162 2163 2164 2165 2166 2167 2168 2169 2170 2171 2172 2173 2174 2175 2176 2177 2178 2179 2180 2181 2182 2183 2184 2185 2186 2187 2188 2189 2190 2191 2192 2193 2194 2195 2196 2197 2198 2199 2200 2201 2202 2203 2204 2205 2206 2207 2208 2209 2210 2211 2212 2213 2214 2215 2216 2217 2218 2219 2220 2221 2222 2223 2224 2225 2226 2227 2228 2229 2230 2231 2232 2233 2234 2235 2236 2237 2238 2239 2240 2241 2242 2243 2244 2245 2246 2247 2248 2249 2250 2251 2252 2253 2254 2255 2256 2257 2258 2259 2260 2261 2262 2263 2264 2265 2266 2267 2268 2269 2270 2271 2272 2273 2274 2275 2276 2277 2278 2279 2280 2281 2282 2283 2284 2285 2286 2287 2288 2289 2290 2291 2292 2293 2294 2295 2296 2297 2298 2299 2300 2301 2302 2303 2304 2305 2306 2307 2308 2309 2310 2311 2312 2313 2314 2315 2316 2317 2318 2319 2320 2321 2322 2323 2324 2325 2326 2327 2328 2329 2330 2331 2332 2333 2334 2335 2336 2337 2338 2339 2340 2341 2342 2343 2344 2345 2346 2347 2348 2349 2350 2351 2352 2353 2354 2355 2356 2357 2358 2359 2360 2361 2362 2363 2364 2365 2366 2367 2368 2369 2370 2371 2372 2373 2374 2375 2376 2377 2378 2379 2380 2381 2382 2383 2384 2385 2386 2387 2388 2389 2390 2391 2392 2393 2394 2395 2396 2397 2398 2399 2400 2401 2402 2403 2404 2405 2406 2407 2408 2409 2410 2411 2412 2413 2414 2415 2416 2417 2418 2419 2420 2421 2422 2423 2424 2425 2426 2427 2428 2429 2430 2431 2432 2433 2434 2435 2436 2437 2438 2439 2440 2441 2442 2443 2444 2445 2446 2447 2448 2449 2450 2451 2452 2453 2454 2455 2456 2457 2458 2459 2460 2461 2462 2463 2464 2465 2466 2467 2468 2469 2470 2471 2472 2473 2474 2475 2476 2477 2478 2479 2480 2481 2482 2483 2484 2485 2486 2487 2488 2489 2490 2491 2492 2493 2494 2495 2496 2497 2498 2499 2500 2501 2502 2503 2504 2505 2506 2507 2508 2509 2510 2511 2512 2513 2514 2515 2516 2517 2518 2519 2520 2521 2522 2523 2524 2525 2526 2527 2528 2529 2530 2531 2532 2533 2534 2535 2536 2537 2538 2539 2540 2541 2542 2543 2544 2545 2546 2547 2548 2549 2550 2551 2552 2553 2554 2555 2556 2557 2558 2559 2560 2561 2562 2563 2564 2565 2566 2567 2568 2569 2570 2571 2572 2573 2574 2575 25

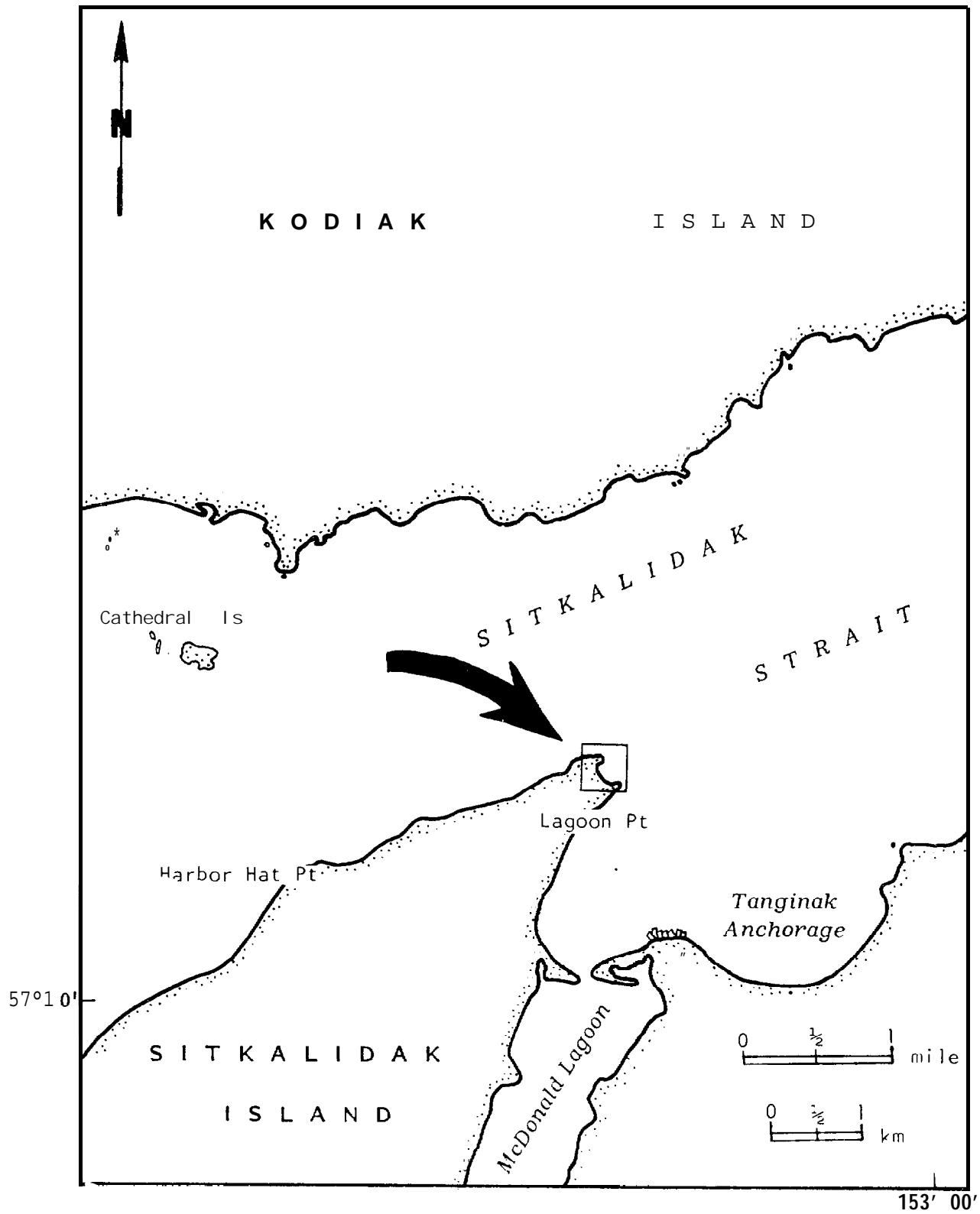


Figure 59. Lagoon Point site.



Figure 60. Lagoon Point, Sitkalidak Island. **Mussel zone along transect line 1 in area of large boulders.**



Figure 61. Lagoon Point, Sitkalidak Island. **Transect line 2. Boulders are considerably smaller than in transect line 1 area.**



Figure 62. Lagoon Point, Sitkalidak Island. Area southeast of transect lines. Size of boulders and width of beach are less than in sampling area.

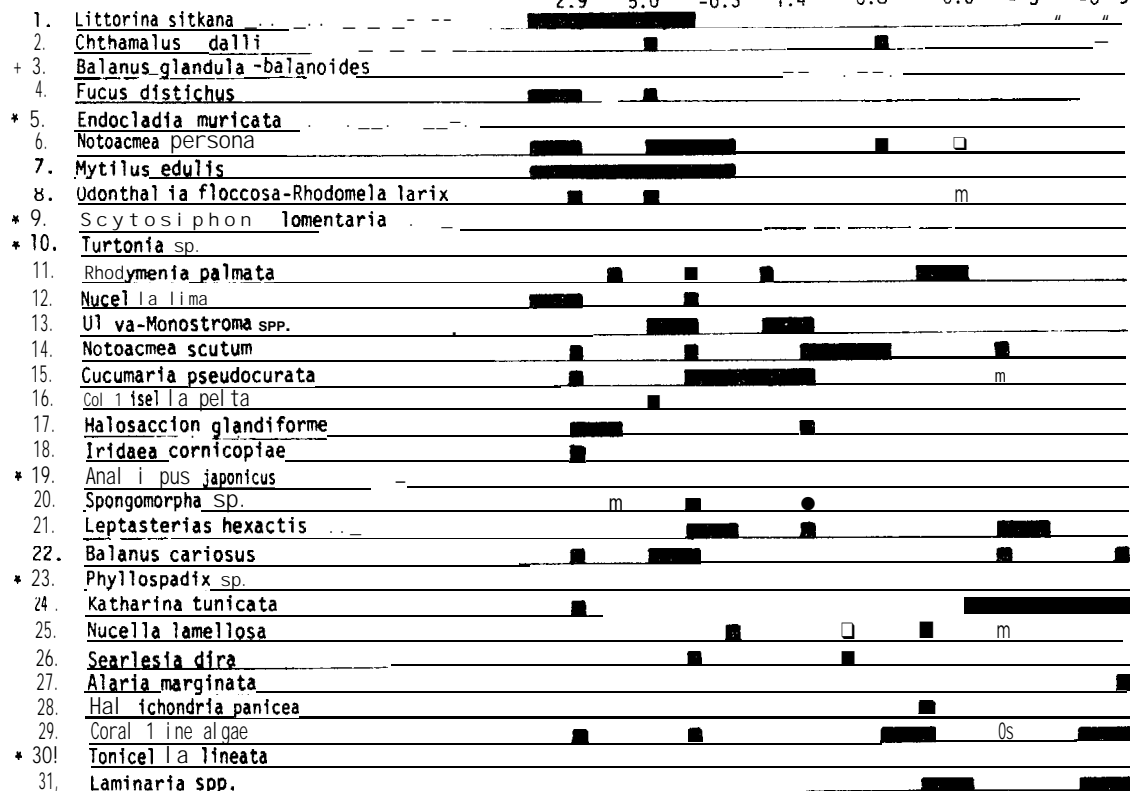
Lagoon Pt.
Intertidal
May 1976

Station 40
Transect 1

Meter No.

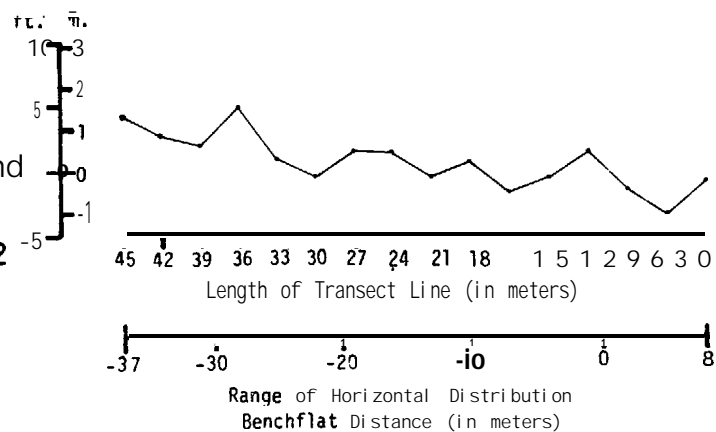
Elevation (in feet)

45 42 39 36 33 30 27 24 21 18 15 12 9 6 3 0
4.1 2.9 2.0 1.0 -0.3 1.6 -0.1 -0.8 -0.6 -0.6 -0.5 -3.2 -0.9

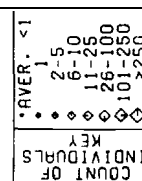


* Species not present in quadrat collections on this transect line.

Fig. 63. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m² quadrats along transect line 1.

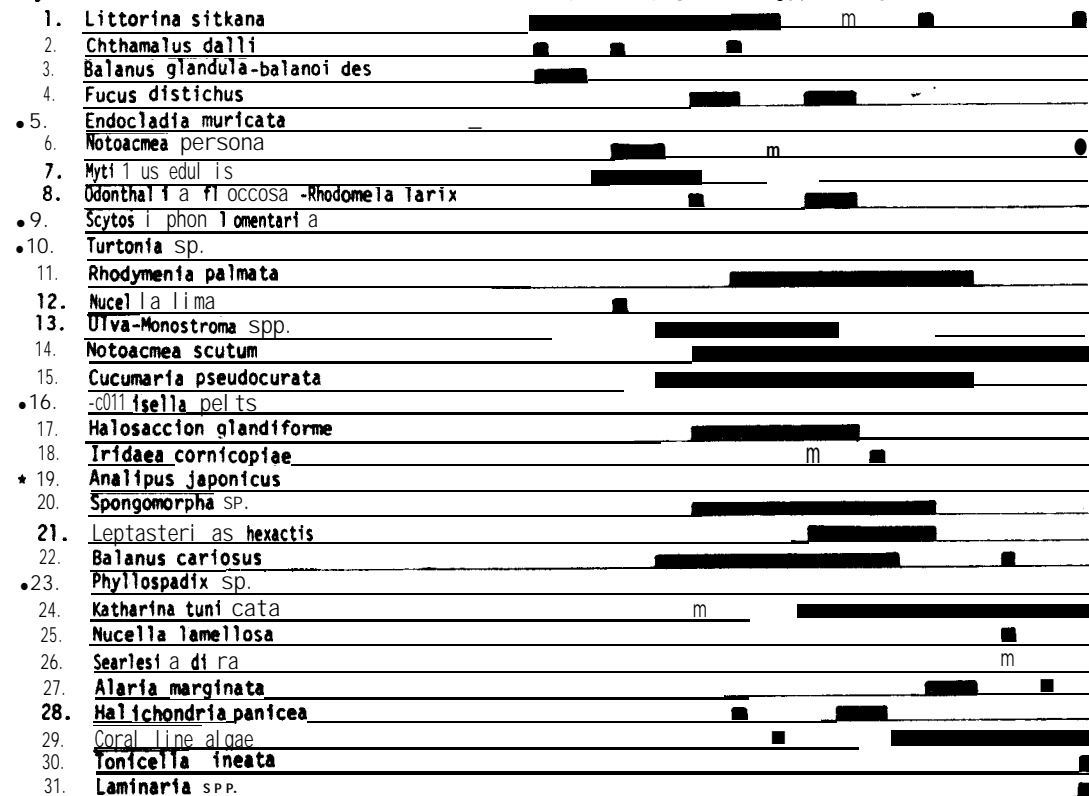


ALGAE



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Lagoon Pt. [] Meter No. 0 3 6 9 12 15 18 21 24 27 30 33 36 39 42
 Intertidal Station 40 Elevation (in feet) 7.6 3.2 2.4 2.2 1.8 0.6 -0.7 -0.5 -0.8
 May 1976 Transect 2 4.7 4.8 2.5 3.0 1.0 -0.2



•Species not present in quadrat collections on this transect line.

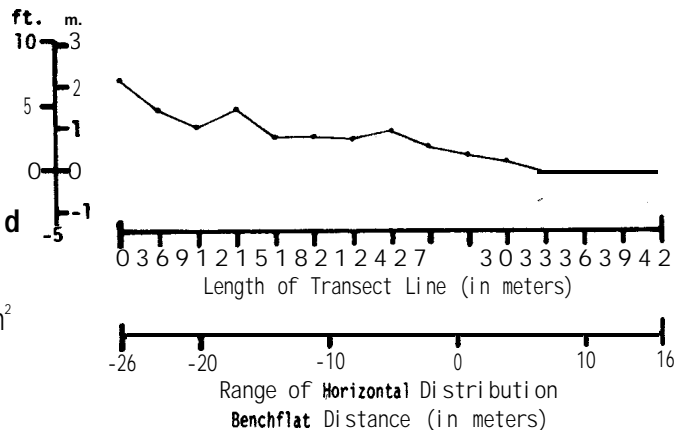
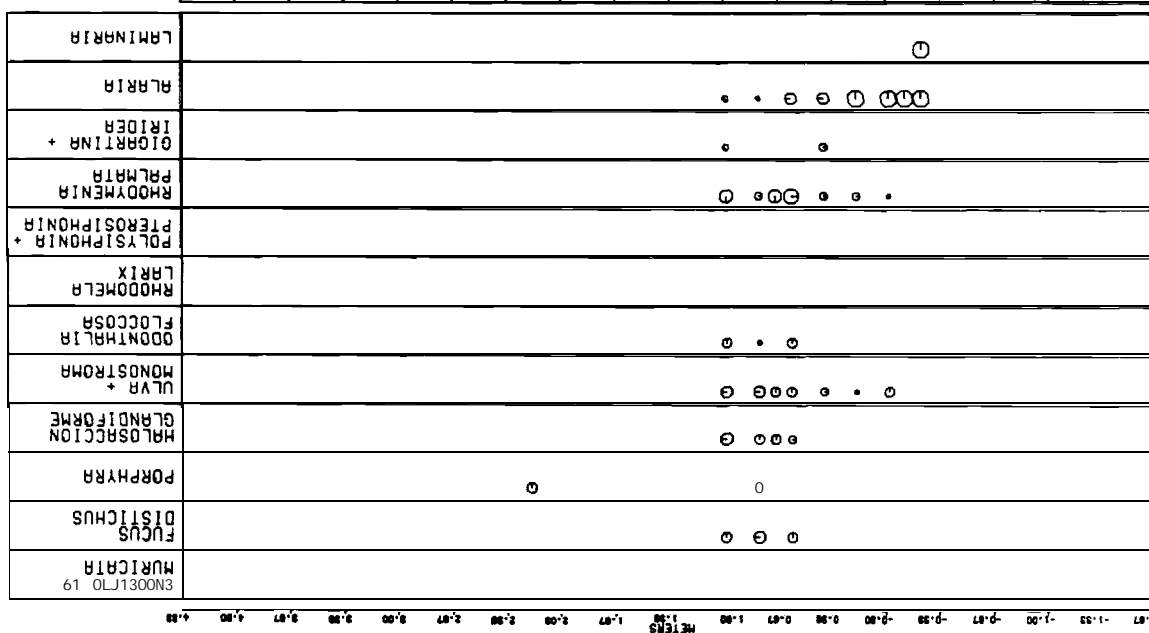


Fig. 65. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m² quadrats along transect line 2.

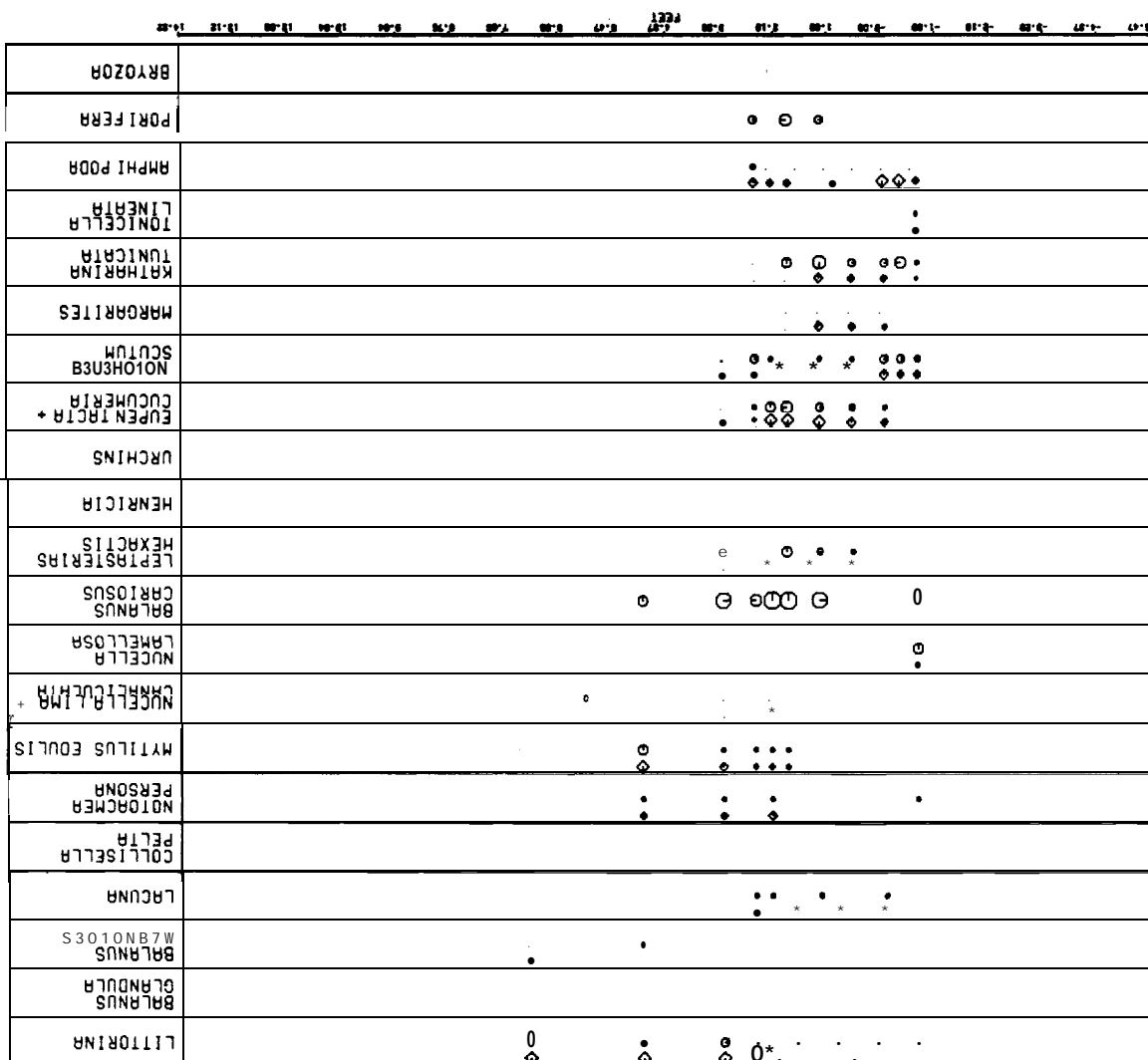
Figure 66. Lagoon Point, May 1976. Densities of selected intertidal organisms along transect line 2.

ALGAE



STATION: LAGOON POINT
 DATE: 76/5/16
 LATITUDE: 57° 1' 30" N
 LONGITUDE: 153° 34' 40" W
 OBSRV. RANGE: -0.2 M TO 2.2 M

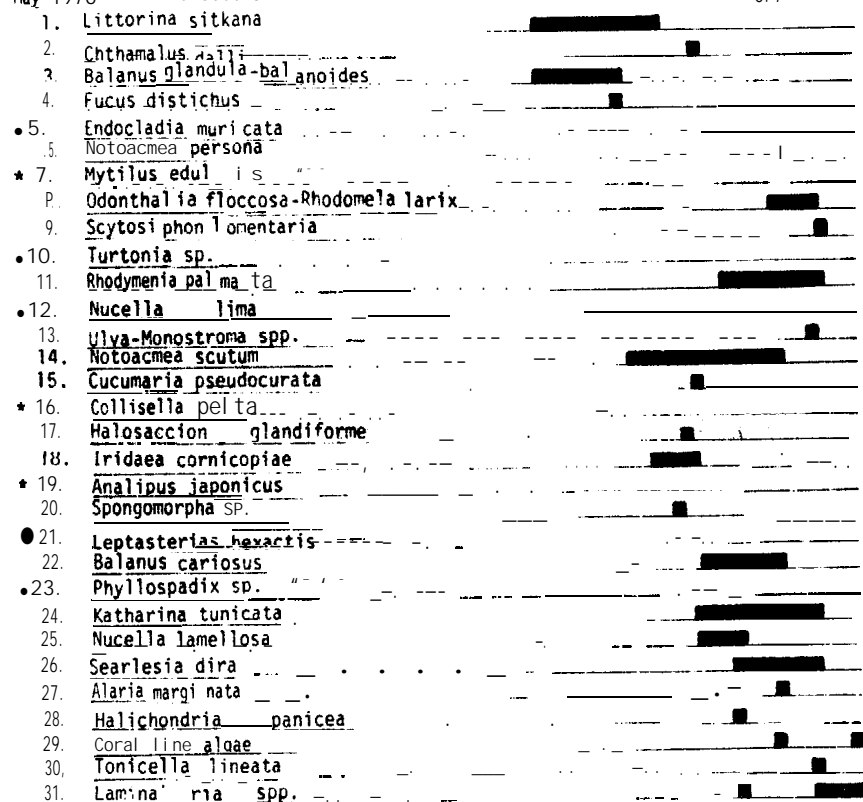
SELECTED NON-RT BRUTES



DRY WEIGHT
 UNITS=GRAMS
 KEY

MET WEIGHT
 UNITS=GRAMS
 KEY

Lagoon Pt. Station 40
 May 1976 Transect 3
 Meter No. 3
 Elevation (in feet) 4.4 2.50.60.3 0.0 -1.5
 -0.7 .1. s



* Species not present in quadrat collections on this transect line.

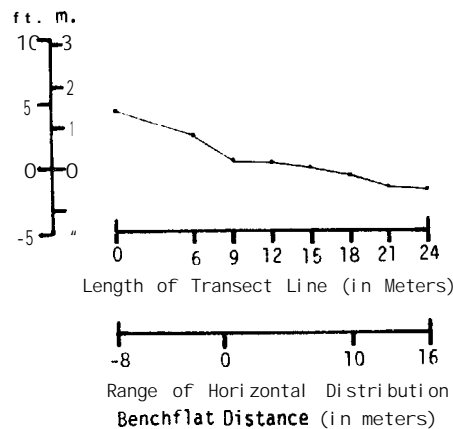
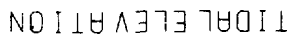


Fig. 67. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m² quadrats along transect line 3.

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reflect this. Sea urchins (Strongylocentrotus droebachiensis) were common, and a small octopus was observed, as well as many large sea anemones. Some species of sea stars (Dermasterias, Pisaster) were not found in the samples but were observed in the immediate area.

Transect 2 (42 m long, sampled at 3-m intervals) was laid in an area with a few large boulders and many small boulders and lacked the varied habitat and invertebrate populations characterizing transect 1 (Figures 65 and 66). Approximately the upper third of the transect lacked algal cover except for a few sprigs of Porphyra. In terms of percent cover, Alaria and the coral line algae were most abundant. Laminaria were abundant in the lowest quadrat and continued into the subtidal range. Rhodomenia were more abundant than in transect 1; often they were found covering boulder tops in an assemblage with bladed green algae and several red algae. Invertebrates were less varied and abundant than in transect 1. In the low zone Balanus cariosus were spatially dominant, chitons and limpets were common, and predatory snails were present. We found littorine snails, limpets, and Balanus balanoides to be spatially dominant along the upper third of the transect.

Transect 3 (24 m long, sampled at 3-m intervals) was approximately 100 m west of transect 2 in an area of even smaller rocks and no large boulders. The distribution of plants and animals in transect 3 (Figures 67 and 68) was similar to transect 2. There were fewer invertebrate species, and density of all species decreased. The sample quadrats missed the Fucus patches in the Fucus zone, so quadrat collection data do not indicate the presence of this zone.

Low Cape (Kodiak Islands)

Low Cape is a flat, small boulder and cobble beach lying on the west shore of Kodiak 'Island and' is exposed from the south and west (Figures 69 and 70). Surf action probably moves the boulders, and vegetation was sparse along the transect (Figures 71 and 72). Rhodomenia larix and Odonthalia floccosa, lying in small discrete clumps, were the most visible algae (Figures 73 and 74). Fucus distichus were sparse and Rhodomenia palmata and Alaria sp. were absent in quadrat collections, although small amounts of bleached Rhodomenia were noted in the vicinity of the transect line. Littorina sitkana and polychaete worms were the only organisms which were found in all 11 samples, while very small Mytilus edulis were found in 10 of 11 samples. The seaward samples had more unique species (occurring in only one sample) and also contained more species.

We also made qualitative observations in an area lying beyond the transect line. Aerial reconnaissance showed that the flat slope of the beach continued for some distance into the subtidal zone, and much of the area we looked at was covered with very large, shallow tide pools. Throughout the area there were a few large and apparently immovable boulders which had different assemblages of organisms than those seen on the transect line. For instance, we saw small- to medium-sized Balanus cariosus on the boulders, often covered with aggregations of the predatory snail Nucella lamellosa. The chiton Katharina tunicata was also observed in this area. Neither Nucella nor Katharina were found in the transect line collections. Many species of red algae were found in the tide pools; these algae were often bleached. Most of the tide pool bottom was covered with coral line algae species, and

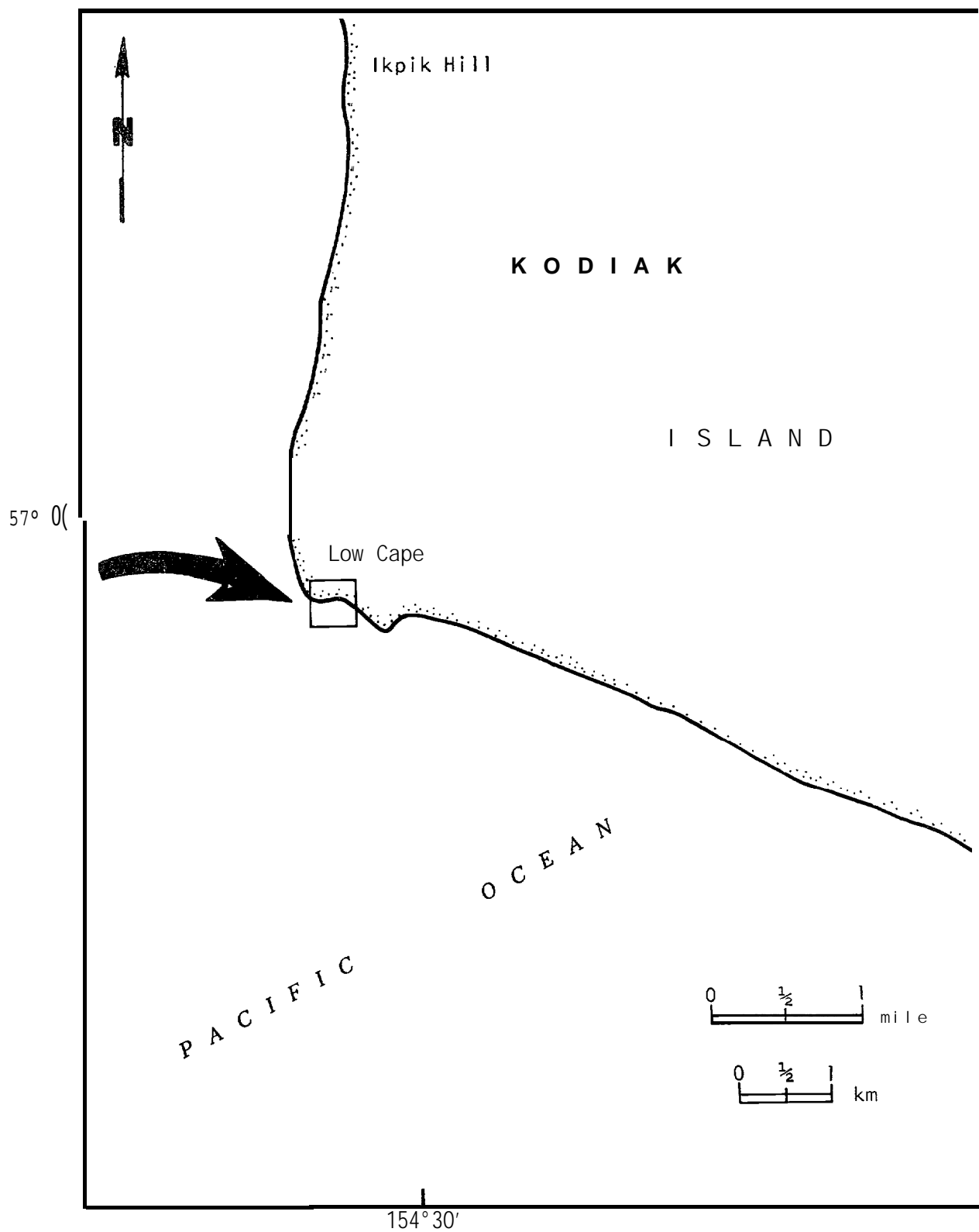


Figure 69. Low Cape site.



Figure T0. Low Cape, Kodiak Island. General view of sampling area looking north.



Figure 71. Low Cape.
Upper end of transect line.

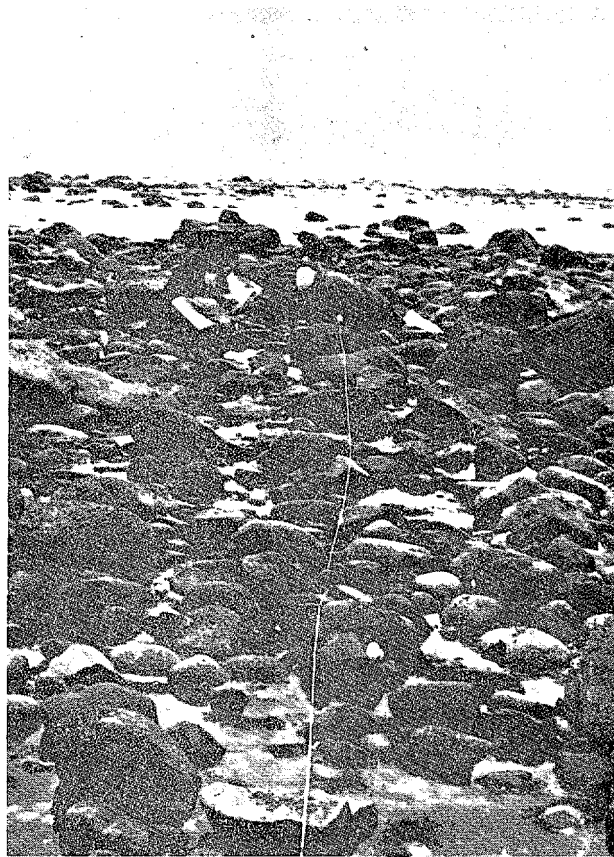
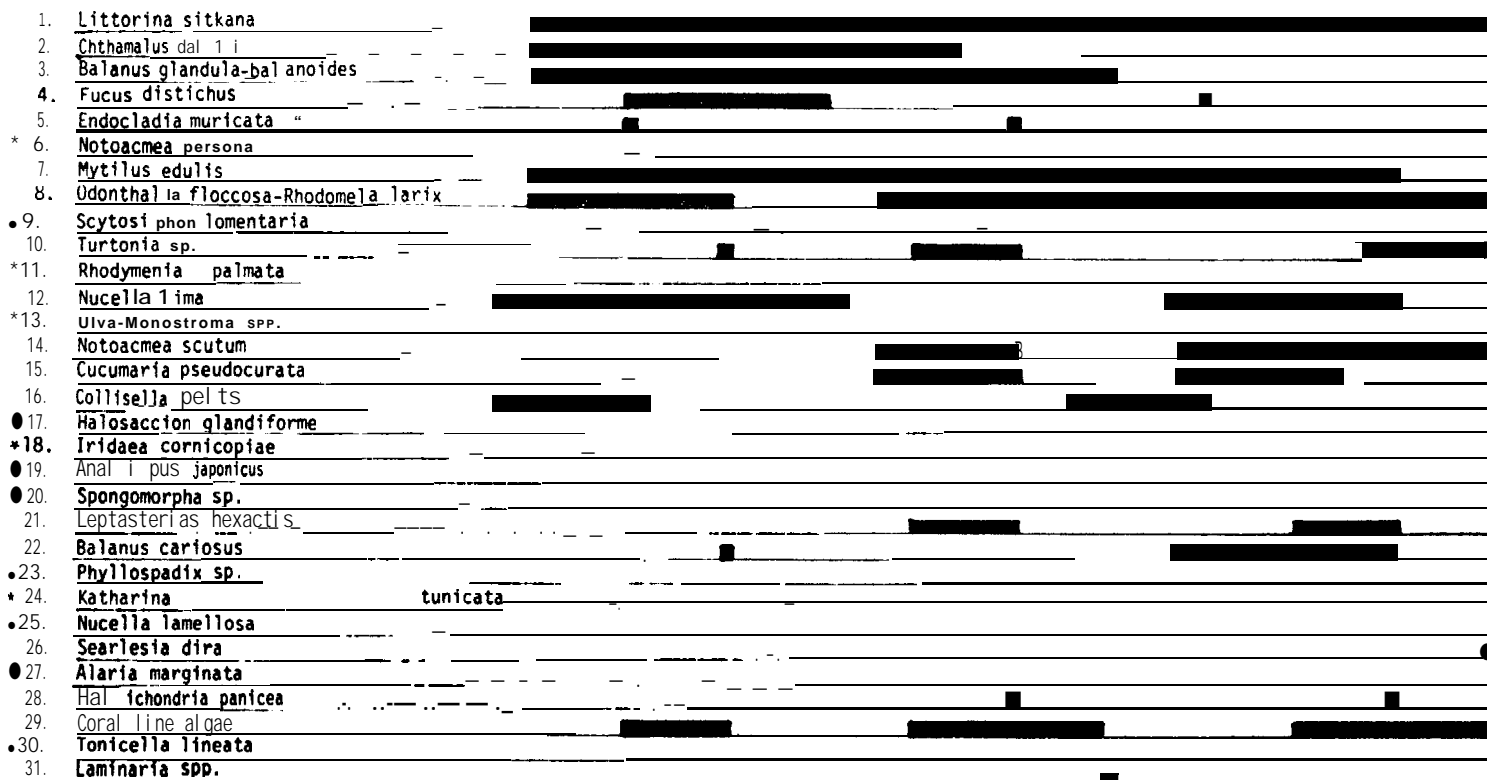


Figure 72. Low Cape.
Lower end of transect line.

Low Cape, Kodiak Island
 Intertidal Station 41 Elevation (in feet) 7.1 135 120 105 90 75 60 45 30 15 0
 May 1976 6.6 5.4 4.8 4.4 3.5 2.5 2.2 1.4 0.6 -1'.0



* Species not present in quadrat collections on this transect line.

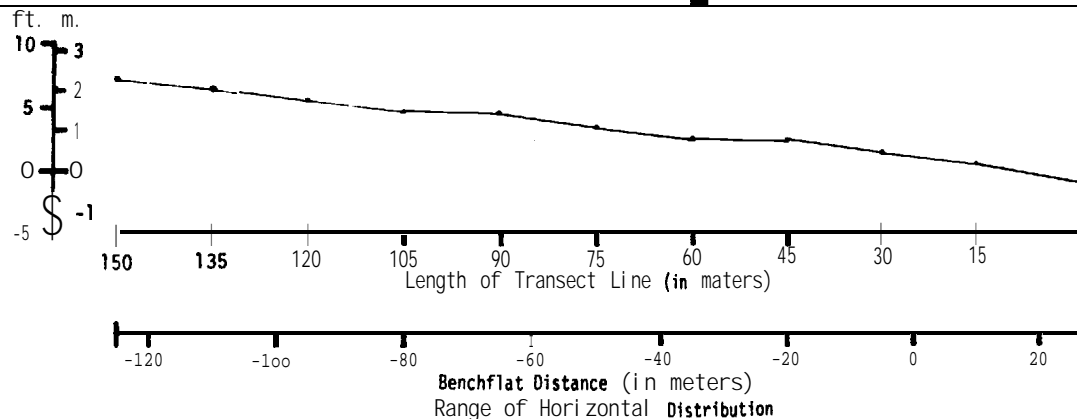


Fig. 73. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m² quadrats along transect line 1.

ALGAE



KEY	COUNT OF INDIVIDUALS
♦	1
♦	2-5
♦	6-10
♦	11-25
♦	26-100
♦	101-250
♦	>250

WET WEIGHT	KEY	UNITS=GRAMS
0000000000	0	0
0000000000	1	1
0000000000	5	5
0000000000	20	20
0000000000	50	50
0000000000	100	100
0000000000	250	250
0000000000	500	500

[illegible]

Constantinea rosa-marina, which generally occur subtidally, were abundant in tide pools. Clumps of Ptilota sp. were also common. Other species included Desmarestia sp. , Laminaria yezoensis, and Alaria sp.

The low beach between the tide pools and the end of the transect line was similar to the terrain along the transect line. Sponges and bleached Lithothamnion covered much of the rock surfaces. Other algae in the area were Laminaria sp. , Halosaccion glandiforme, Bangia sp., Ulva sp., and Fucus.

Dolina Point (Sitkinak Island, Trinity Islands)

Dolina Point is a flat bedrock point lying along gravelly and sandy beaches on the north coast of Sitkinak Island, Trinity Islands (Figure 75). The point is separated from the beach by a small boulder and cobble bar of lower elevation than the top of the bench. The transect line extended 190 m shoreward from the center of the bench across the bar (Figures 76 and 77).

The distribution and density of selected species are shown in Figures 78 and 79. The outer portion of the transect line crossed rough bedrock covered mainly with Balanus cariosus. Vegetation was light, most commonly Alaria and Odonthalia. The middle portion of the line ran through a mixed area of bedrock, gravel, sand, and standing water. Phyllospadix serrulatus* was growing in small patches in this area. The shoreward portion of the line was cobble beach. Vegetation was small, dense, discrete clumps of Fucus distichus, Rhodomelalarix, and Odonthalia floccosa. One-meter-square sample quadrats were used for sampling algae in this section.

Both quadrat collections and visual enumerations showed the dominance of Fucus, Odonthalia, and Rhodomela, as well as the presence of Endocladia muricata, Phyllospadix, and bladed green algae. Alaria sp. were dominant in the quadrats lying in the bedrock portion of the transect line. The distribution of invertebrates was fairly homogeneous along the transect. The most common inhabitants of the cobble area in the upper intertidal zone were limpets, snails, amphipods, and the small sea cucumber Cucumaria. Species of Balanus were not found in the cobble area except for a few Balanus cariosus. The species composition of the bedrock portion of the transect was similar to the cobble portion, but B. cariosus were common in the low area, and chitons, Katharina tunicata, were found in the quadrat collection nearest the water.

Qualitative Surveys: Description of Sites and Biota

On qualitative surveys, two biologists recorded what they observed but made no collections. It is inevitable that some species, particularly motile invertebrates, may have been overlooked on these brief surveys, but the site descriptions provide a general idea of the habitat types and most conspicuous plants and animals present. A map and photographs accompany the

* Identification by Ronald C. Phillips, Seattle Pacific University, Seattle, Wa., personal communication.

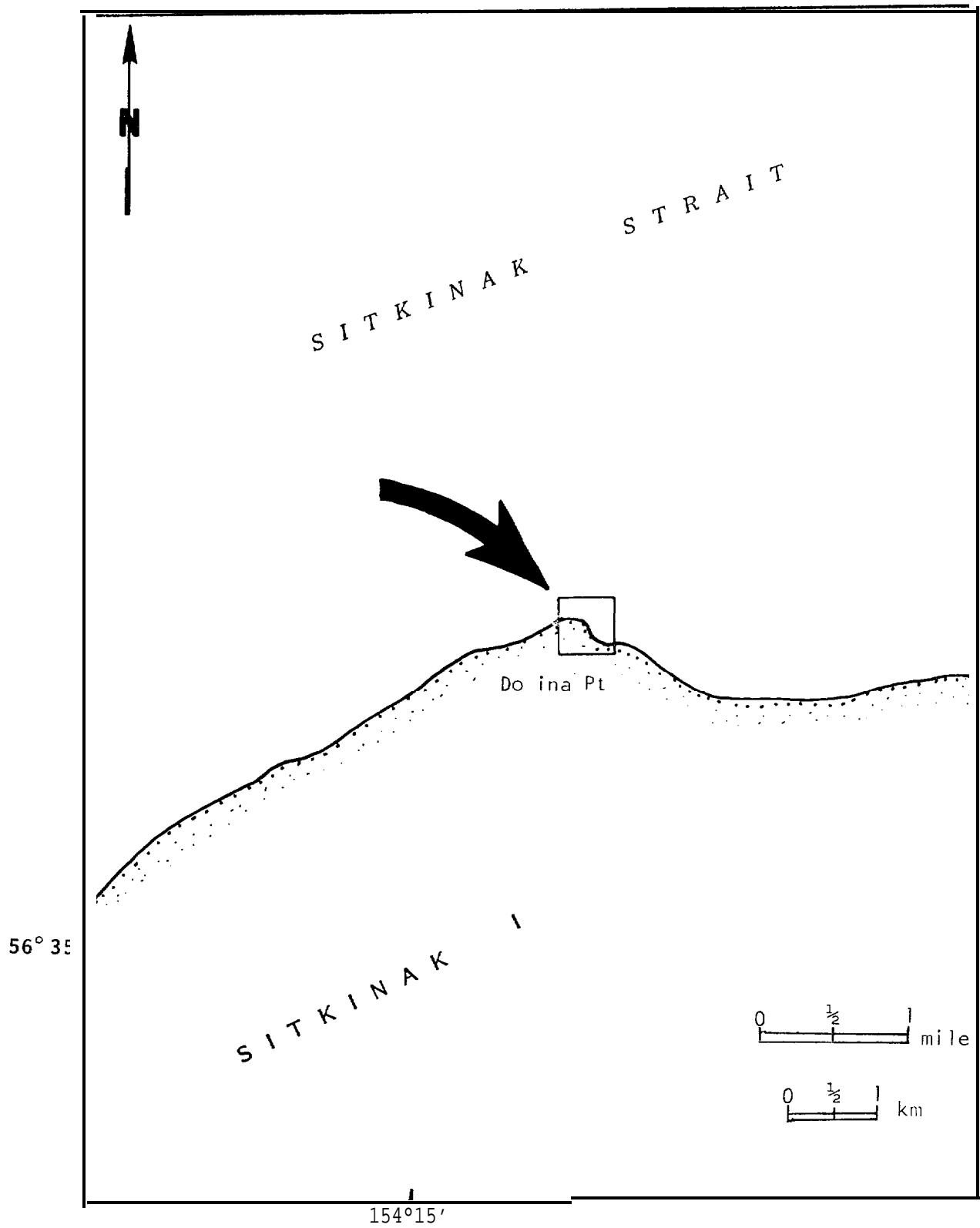


Figure 75. Dolina Point site.

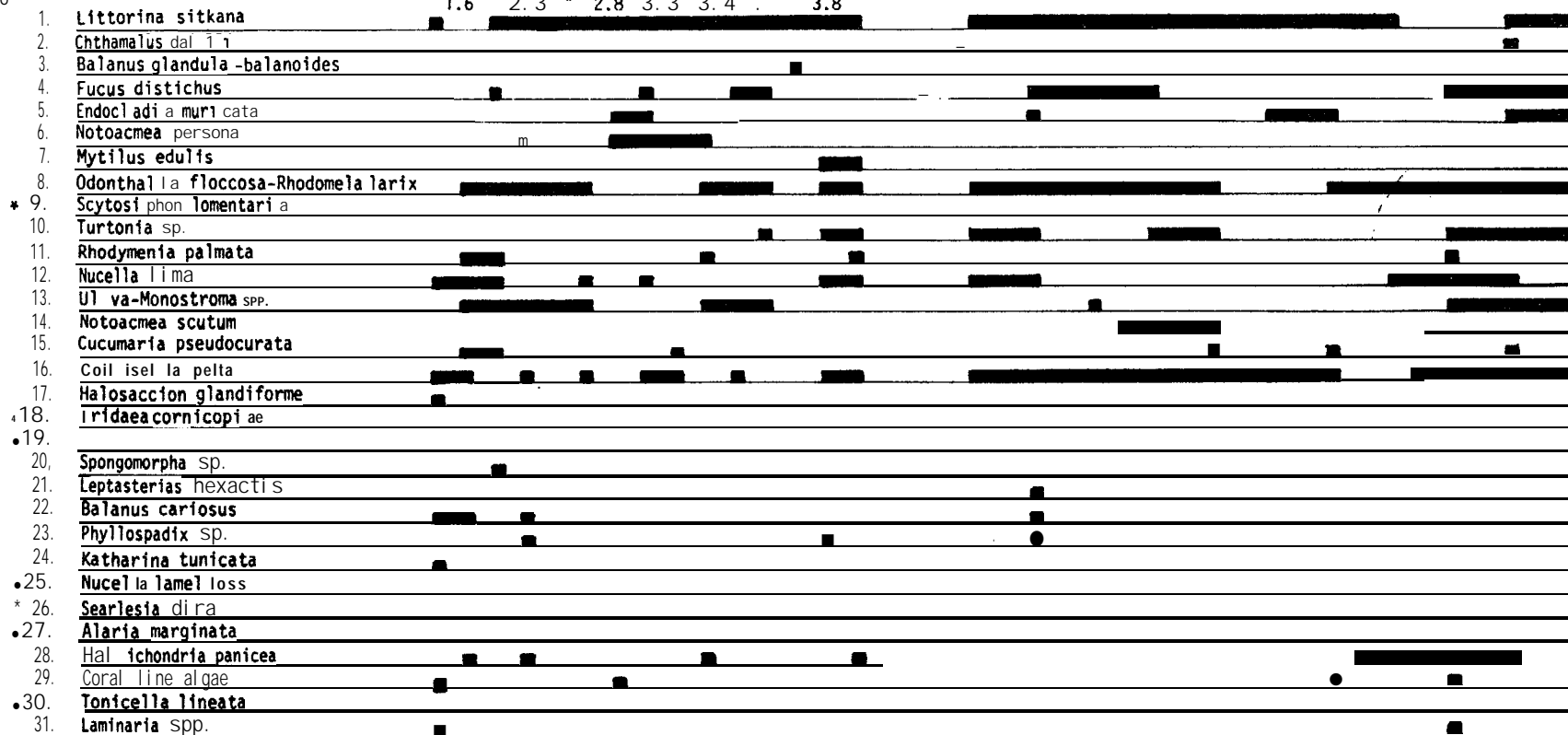


Figure 76.
Dolina Point, Sitkinak Island.
Upper end of transect line.
Quadrats along this portion
of the line were $1/16 \text{ m}^2$.



Figure 77. Dolina Point, Sitkinak Island. Lower end of transect line.
Quadrats along this portion of the line were $1/16 \text{ m}^2$.

Uolima Pt. Station 39 Meter No. Elevation (in feet) 0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 **80 90 100 110 120 130 140 150 160 170 180 190
 Intertidal May 1976 4.1 3.5 2.2 3.2 3.0 3.5 3.2 3.7 4.0 4.1 3.9 4.0 4.2 3.9 3.8 3.6 2.9 3.0 3.5



Species not Present in quadrat collections on this transect line.

**no sample collected at m 80

● tide pool

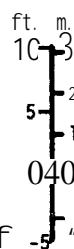


Fig. 78. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m² quadrats along transect line 1.

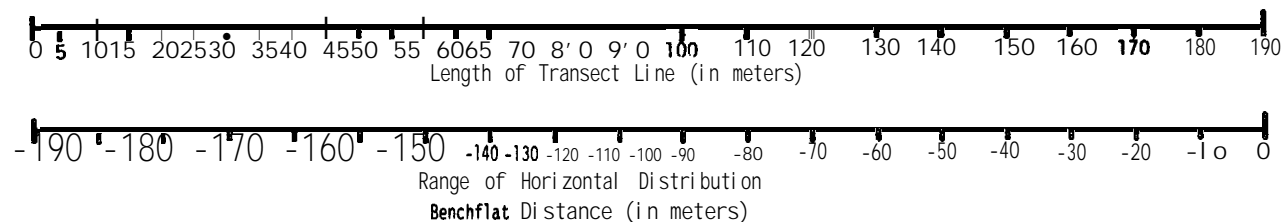
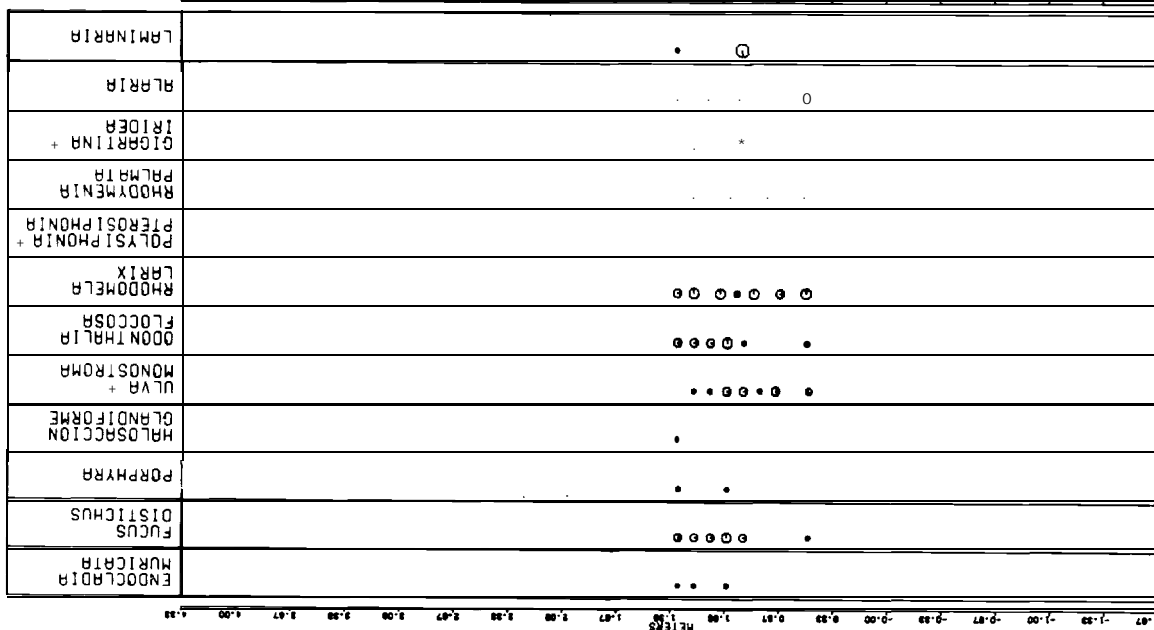


Fig. 79. Dolina Point, May 1976. Densities of selected intertidal organisms along transect line 1.

ALGAE



STATION: DOLIN^{PO} T
 DATE: 76/ 5/14
 LATITUDE: 56 36 90 N
 LONGITUDE: 154 13 20 W
 OBSRV. RANGE: 0.5 M TO 1.3 M

COUNT OF INDIVIDUALS
 KEY
 0.1-0.5
 0.6-1.0
 1.1-1.5
 1.6-2.0
 2.1-2.5
 2.6-3.0
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description of each site we surveyed qualitatively. Summary descriptions of the sites we sampled qualitatively are in Table 6.

Table 6.--Description of intertidal sites in the Kodiak Island area, 1975-76! sites sampled qualitatively.

Location	Exposure	Substrate	Date Sampled
Middle Geese Is.	Exposed	Flat bedrock	7-12-76
Narrow Cape	Exposed	Flat bedrock	7-11-76
St. Paul Harbor	Protected	Flat bedrock	7-11--76
Sea Otter Is.	Exposed	Hummocky bedrock or boulder	7-13-76
Pillar Cape	Exposed	Hummocky bedrock or boulder	7-14-76
Spruce Island	Exposed	Hummocky bedrock or boulder	7 -9-76
Tonki Bay	Protected	Hummocky bedrock or boulder	7-14-76
North Shuyak Is.	Protected	Hummocky bedrock or boulder	7-13-76
Whale Island			
Site 1	Protected	Small boulder	7-10-76
Site 2	Exposed	Small boulder	7-10-76

Middle Geese Island (Geese Islands)

The three Geese Islands lie near the southeast tip of Kodiak Island. All three islands are small, the largest approximately 2.5-km long. Between and around this island group is an area of shoal water and reefs. From the air the shoals appear to be profusely covered with kelp and surf grass. In 1913 Rigg described the area as having the second largest kelp concentration in the Kodiak Island area.

We qualitatively sampled three sites on Middle Geese Island in July 1976 (Figure 80). All were topographically similar, being long, flat bedrock areas backed by sandy or cobble beaches and high (30 m) grassy bluffs (Figure 81) above the low tide line. They differed slightly in exposure, and one site had a few vertical outcropping approximately 3 m high.

At all three sites large tide pools were not common, but drainage across the extensive flat benches appeared to be slow and the entire area remained wet when the tide was out. Intertidal areas had a lush cover of algae and zonation was not apparent. Several large areas were completely covered with surf grass (Phyllospadix) (Figure 82)

Some parts of the uppermost intertidal area were covered with extremely high numbers of littorine snails, especially in exposed areas, but most organisms characteristic of upper intertidal zones (Fucus distichus, Porphyra, Balanus glandula, Collisella pelta) were generally limited to the few rock tops which occurred on the low-relief bench.

In the upper intertidal zone at all three sites we found assemblages consisting primarily of Gigartina sp. and Ulva sp. with localized high densities of Ptilota sp., Seytosiphon sp., Odonthalia floccosa, and Halichondria panicea. Species such as Mytilus edulis and Balanus cariosus, which are usually common at this tide level, were low in abundance. Algae in the lower intertidal zone were Alaria sp. and Hedophyllum sessile. There was an understory of coralline algae, the alga Rhodomenia palmata, and the sponge Halichondria. Large numbers of Fusitriton oregonensis were found laying or guarding eggs. A few Katharina tunicata, Tonicella lineata, Strongylocentrotus droebachiensis, Leptasterias hexactis, and Henricia leviuscula were also encountered. Large beds of Phyllospadix also occurred in the area but were most abundant in proximity to kelp (Laminaria) beds.

Within this general pattern, some differences were evident between sites. At the first site, on the exposed south side of the island, there were large drift accumulations of rotting algae which were absent at the second site on the more protected north shore, and the intertidal zone was much wider than on the more protected northern site, which had larger numbers of starfishes and Margaritas, and a wider, more prominent Fucus zone that was not limited to rock tops.

At the third site, on the eastern tip of the island, the same general assemblages occurred on the flats but there were also several large (3-m high) hummocks (Figure 83). On the protected side of the hummocks we found dense bands of mussels and Balanus cariosus. These were being preyed upon by the starfish Evasterias. Other common invertebrates included Henricia, Katharina, and Notoacmea scutum. Abundant algae included Fucus, Odonthalia, Porphyra, Rhodomenia, and Endocladia muricata. On the exposed faces, Mytilus and Evasterias were uncommon.

Narrow Cape (Kodiak Island)

Narrow Cape (Figure 84) on the northeastern side of Ugak Bay, approximately 35 km southeast of the city of Kodiak, is exposed to the full force of the ocean. The sampling area was backed by high (50 m) bluffs which broke abruptly into a nearly flat beach extending several hundred feet seaward. Our sampling area was in the Twin Lake area. Two sites within walking distance of each other were qualitatively examined in July 1976.

The first site was a bedrock shelf of very low gradient and low relief (Figure 85). As on many other exposed flat bedrock beaches with standing water around Kodiak, surf grass (Phyllospadix sp.) was a prominent member of the

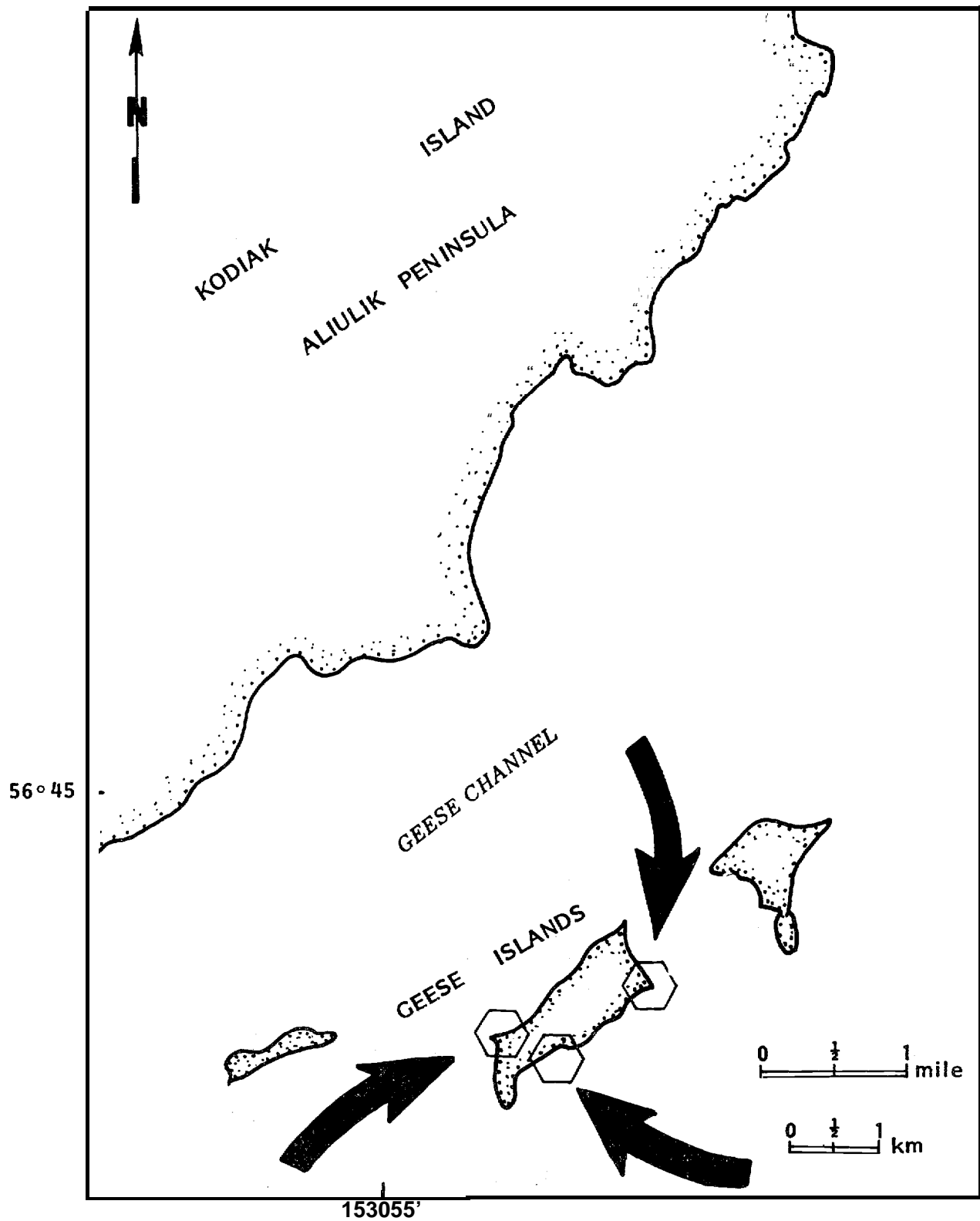


Figure 80. Middle Geese Island site.



Fig. 81. Middle Geese Island.
General view of study area.

Figure 82. Middle Geese Island. Phyllospadix sp.,
an abundant surf grass.

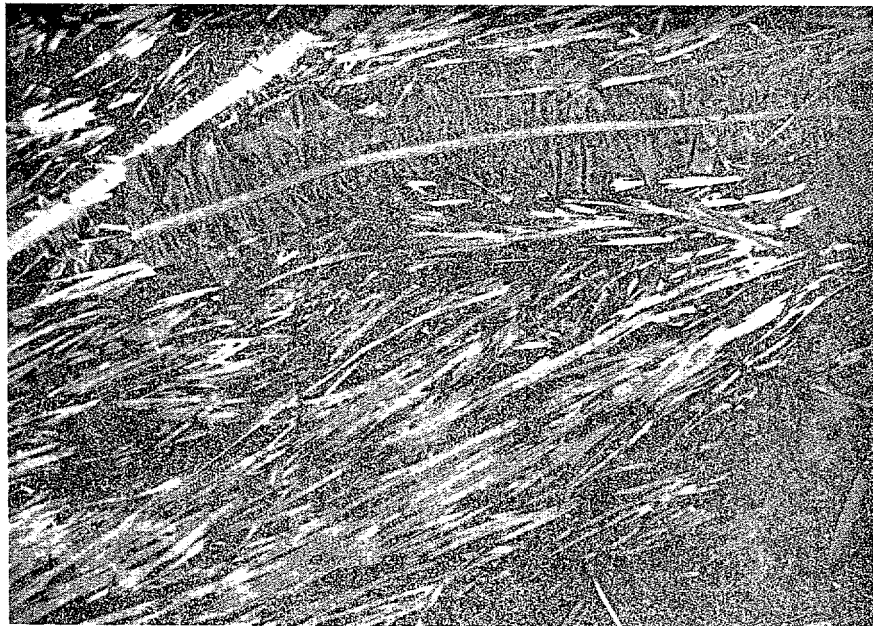




Figure 83. Middle Geese Island. General view of third study area; **this area** included several large hummocks.



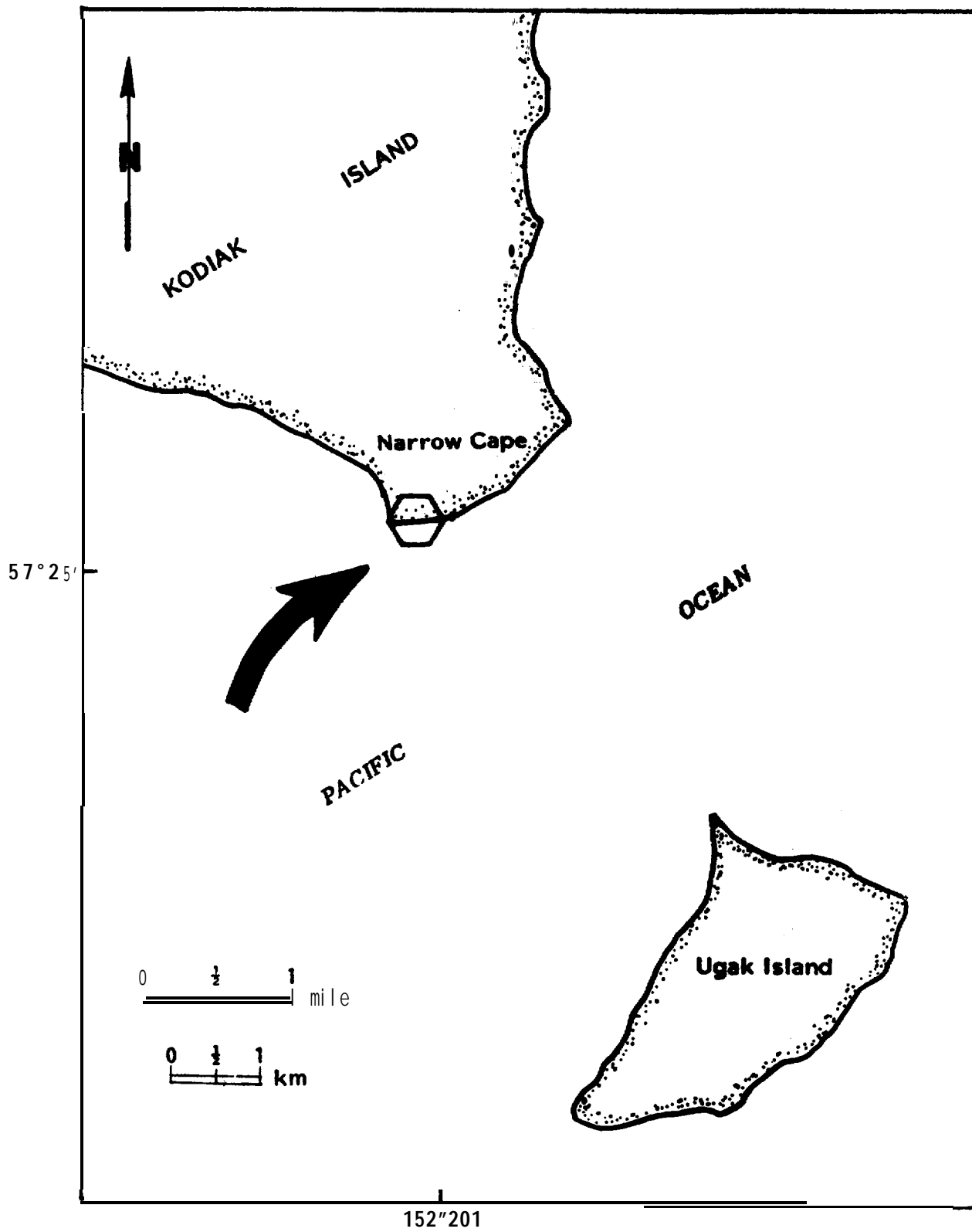


Figure 34. Narrow Cape site.



Figure 85. General view of the Narrow Cape study area.

community, and predatory invertebrate species such as starfishes and Nucella lamellosa were not apparent. Unlike many other exposed sites, however, mussels (Mytilusedulis) were common in some local areas.

Although zonation was obscured due to the flatness of the beach and the presence of Phyllospadix, certain trends were apparent. The intertidal areas farthest from the water contained patchy growths of Fucus distichus, Endocladia muricata, Ralfsia sp., and Balanus glandula. Small limpets (probably Acmaea strigatella or Collisella pelta) grew in profusion. Littorine snails were also quite common.

Closer to the water were areas covered with Odonthalia floccosa and Balanus cariosus. A few Nucella lima were also found. The limpet Collisella was common here and was being harvested by people from Kodiak. Tide pools in this area contained dense growths of Phyllospadix along with Odonthalia floccosa and Alaria sp.

Near the water was a wide zone covered with lush growths of Alaria sp. The understory consisted of patches of Rhodomenia palmata, Balanus cariosus, and Halichondria panicea. Katharina tunicata and one Leptasterias hexactis were also collected at this level.

The second sampling site had large numbers of boulders lying on the bedrock substrate. The biota were similar to the first site except that sessile invertebrate populations (Mytilus, Balanus) were more evident as they had heavily colonized the rock faces.

St. Paul Harbor (Chiniak Bay, Kodiak Island)

St. Paul Harbor lies in Chiniak Bay between the city of Kodiak and the airport (Figure 86). Because of its proximity to industrial development, we would normally not have chosen such an area. However, poor flying conditions in July 1976 forced us to set down soon after the helicopter took off, and we investigated this site while waiting for better weather.

The area is heavily impacted by human activity. A recreational road and trail system ends approximately 400 m from the beach and the intertidal zone is backed by a high berm composed of military junk. The waters seaward of the site are heavily traveled by fishing boats. The intertidal substrate itself is composed of a shale-like bedrock bench which is broad, flat, and contains many tide pools.

Perhaps because of the close proximity to many large fish-processing plants, the filter-feeding invertebrate life here was among the richest seen anywhere in the Kodiak Island area. An extremely heavy cover of barnacles, mussels, sponges, bryozoa, and sabellid worms occurred throughout the area. These invertebrates seemed to be crowding out the algal flora. Algae which had been able to establish themselves seemed in poor condition, possibly due to grazing herbivores such as sea urchins, which were common. The Alaria population seemed particularly impacted by herbivores and, in many areas, rows of bare stipes were all that remained. Although the urchins may have been the main grazer on mature macrophytes, limpets and chitons were also found in profusion and may have been limiting the development of earlier stages of macroalgae.

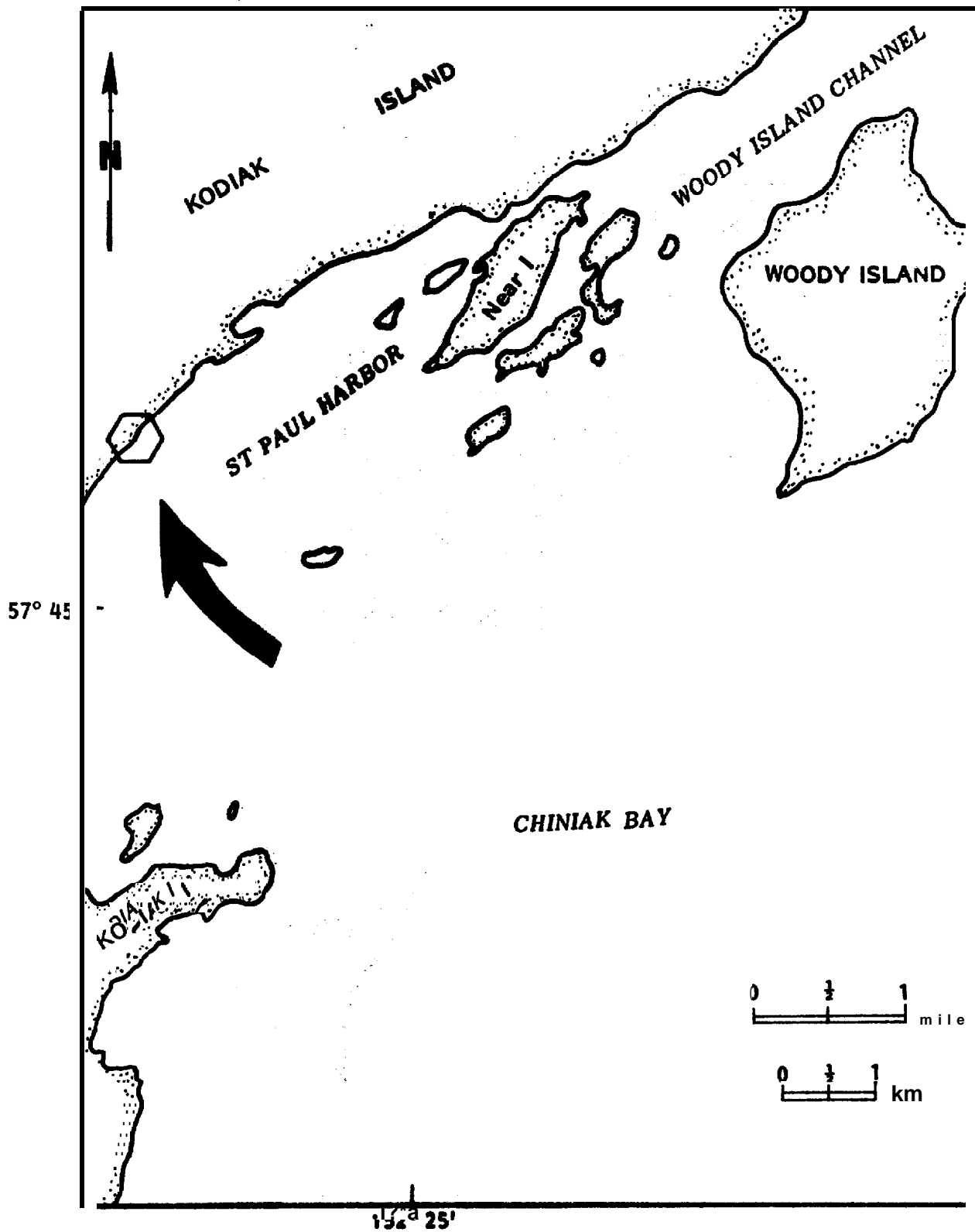


Figure %6. St. Paul Harbor site.

Possibly because of the rich invertebrate fauna and the general protection from wave action, there were also large numbers of carnivores, mainly starfishes (Evasterias) and gastropod (Nucellalamellosa).

The distribution of invertebrates was homogeneous due to the flatness of the beach and the presence of tidepools (Figure 87). Generally, the higher levels contained large populations of Littorina sitkana, Balanus glandula, and Collisella digitalis. Common algae included Porphyra sp. and Endocladia muricata. Nucellalamellosa was a common predator at this level.

Below this area was a zone heavily covered with Balanus cariosus and Mytilus edulis. Competition for space was apparent; in many areas the mussels had almost completely overwhelmed populations of large B. cariosus and a recent set of Balanus sp. had almost completely covered the surfaces of the mussel shells.

Close to the water was a zone of fertile Fucus distichus and Odonthalia floccosa which graded into an area of heavily-grazed Alaria sp. The understory in the Alaria-covered area consisted of very heavy growths of B. cariosus, Halichondria panicea, and sabellid worms (Figure 88).

Several tide pools were also investigated. Pools farthest from the water in areas corresponding to the level of the Mytilus zone contained the algae Rhodomela larix, Odonthalia sp., Microcladia sp., and Rhodymenia palmata; coral line algae; and the sponge Halichondria. Mid-level pools had similar algae and also included Alaria sp. and Hedophyllum sess.ii, as well as the chiton Katharina tunicata. Pools closest to the water were quite full of Alaria sp. along with occasional large populations of tube worms or urchins. Surf grass (Phyllospadix) was found growing in tide pool depressions at several tidal levels.

Sea Otter Island

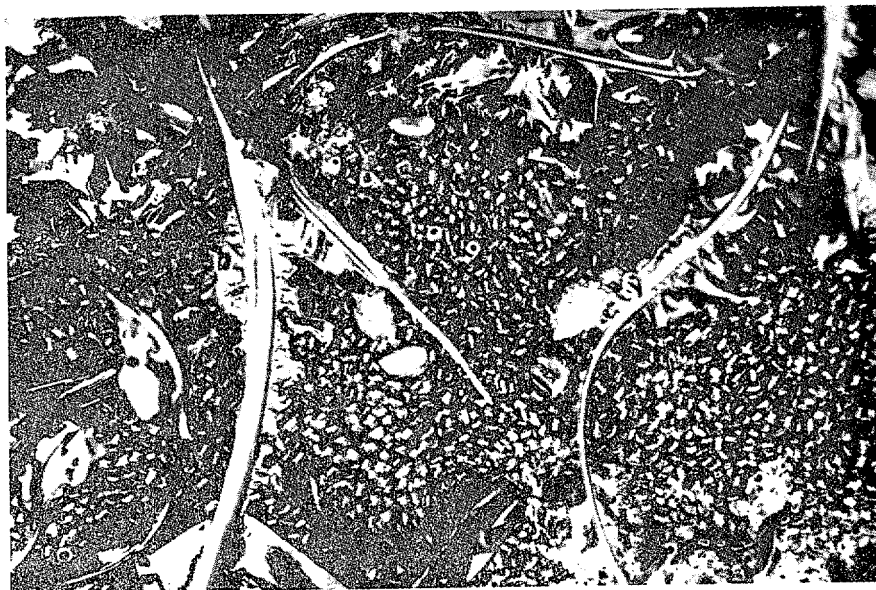
Sea Otter Island (Figure 89) is a small (0.6 km long), highly-exposed island lying approximately 5 km off the coasts of Afognak and Shuyak Islands. The beach is moderately sloping and composed of tilted and fractured bedrock (Figure 90). The island is low (30 m) and grassy, and has large concentrations of sea birds including puffins and gulls. Birds had apparently been feeding on intertidal invertebrates, as indicated by the many empty chiton and limpet shells strewn over the island. Another evidence of utilization of this area by birds was the large amount of Prasiolameridionalis which was growing very high in the intertidal zone. This species of algae usually only occurs in areas of high guano concentration,

When we qualitatively investigated this island in July 1976, it appeared that several generally common invertebrate species were only present in small numbers. Balanus glandula and Mytilus edulis were uncommon, being mainly confined to cracks or crevices in the bedrock. Littorine snails were not common. Predators such as sea stars or carnivorous gastropod (Nucella, Searlesia) were generally absent unless they were small enough to hide in crevices. Although limpets and chitons were also uncommon, concentrations of shells were found in areas utilized by birds.



Figure 87. General view of St. Paul Harbor study area.

Figure 88. Large colonies of sabellid worms which were common at St. Paul Harbor. Note predation by Nucella sp.



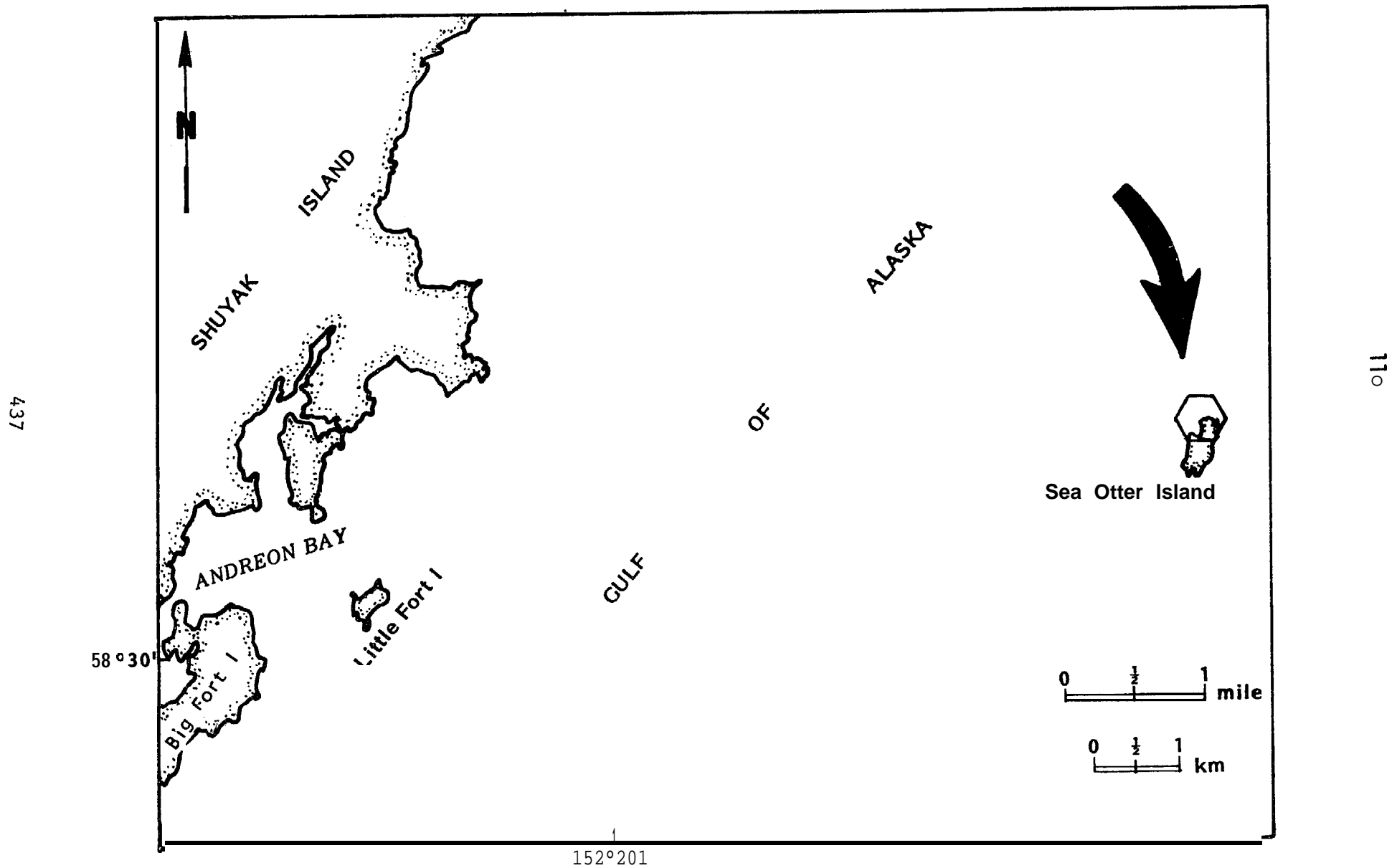


Figure 89. Sea Otter Island site.



Figure 90. Sea Otter Island. General view of bedrock intertidal area.

Figure 91. Sea Otter Island. General view of sampling area showing heavy Alaria cover.



The area was heavily covered by algae (Figure 91). At the highest intertidal levels we found Prasiola and Porphyra sp. A band of Halosaccion glandiforme grew below this and graded into a belt dominated by Rhodymenia palmata f. sarniensis. Both the Halosaccion and Rhodymenia bands were almost monoalgal in nature. Even Fucus distichus and Odonthalia floccosa did not occur in these zones.

At the lower intertidal level Alaria sp. and Laminaria longipes were dominant. They were growing over an understory of Gigartina sp., Balanus cariosus, Halichondria panicea, and coralline algae. Farther out, in the area not exposed by the tides, large beds of Laminaria sp. were observed.

Pillar Cape (Afognak Island)

Pillar Cape lies in a highly exposed location on the eastern side of Afognak Island (Figure 92). Surf in the area is high and the spray zone extends a long distance from the edge of the water.

We qualitatively studied two sites in July 1976. The first was a hummocky bedrock beach (Figure 93) and the second was covered with very large boulders. Both were surrounded by sandy and gravelly beaches (Figure 94). The large amount of bare rock surface seen at all levels at both sites may be indicative of the effect of high wave force combined with the scouring effect of sand and gravel in suspension. Many of the smaller rocks were completely bare of attached organisms.

Biota and zonation were similar at both sites, and generally common forms such as starfishes, sea urchins, and predatory snails (Searlesia, Nucella) were apparently absent. Mussel and barnacle populations were small relative to populations in more protected locations.

The upper area had patchy growths of Porphyra sp. and Halosaccion glandiforme. Littorine snails were common. The middle zones had patchy growths of Rhodymenia palmata, with occasional large populations of Collisella pelta or patches of Balanus cariosus. A few small Mytilus edulis were found growing in cracks and crevices. The lowest zone had sparse to occasionally heavy cover of Alaria sp. with an understory of Rhodymenia, filamentous green algae, and a few Tonicella lineata, B. cariosus, and Mytilus growing in crevices.

Spruce Island

Spruce Island (Figure 95) lies near the northeastern tip of Kodiak Island approximately 13 km from the city of Kodiak. It forms part of the land mass which borders the southern side of Marmot Bay. The coastal substrate generally consists of deeply cleaved bedrock but small sandy beaches are not uncommon.

Our sampling area was on the southeastern tip of Spruce Island and was exposed to storms and surge from the northeast and east. Five sites were qualitatively examined in July 1976 and the presence or absence of common species was noted. Sites one and two were tall rock faces (Figure 96), sites three and four were moderately sloping hummocky bedrock, and site five had a very low-relief, almost flat, bedrock substrate with small pools of standing water.

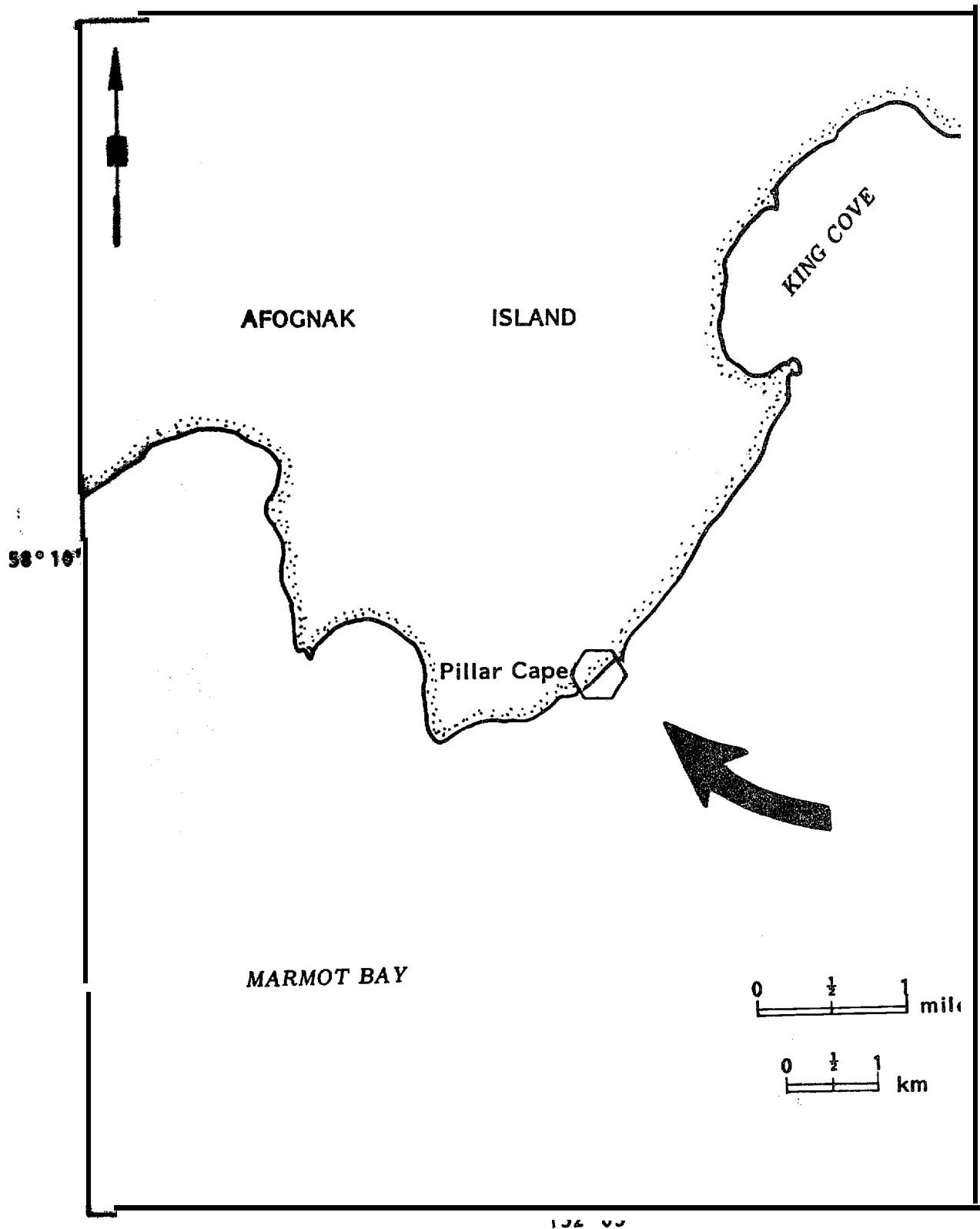


Figure 92. PillarC ape site.



Figure 93. View of Pillar Cape site showing extensive bare rock.

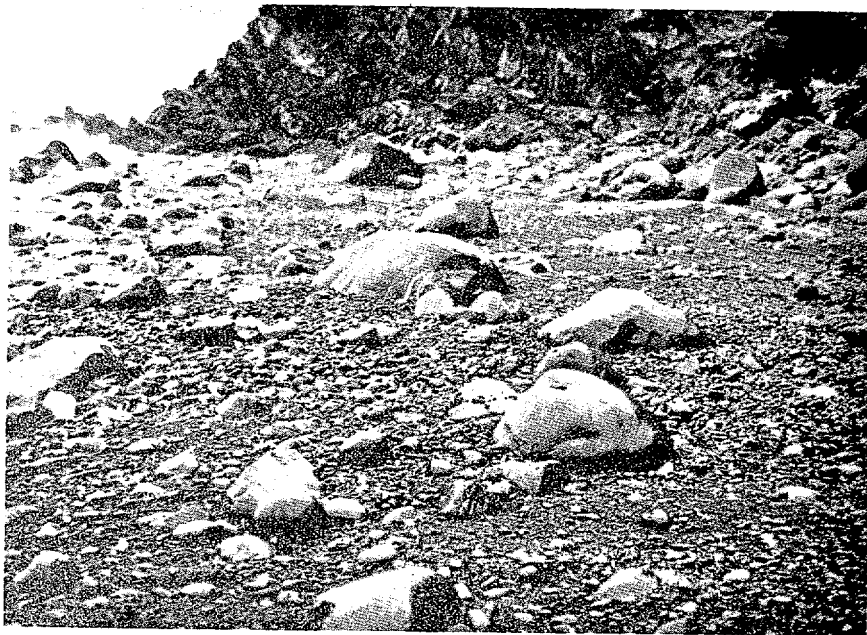


Figure 94. View of Pillar Cape site showing paucity of attached biota on unconsolidated beach material.

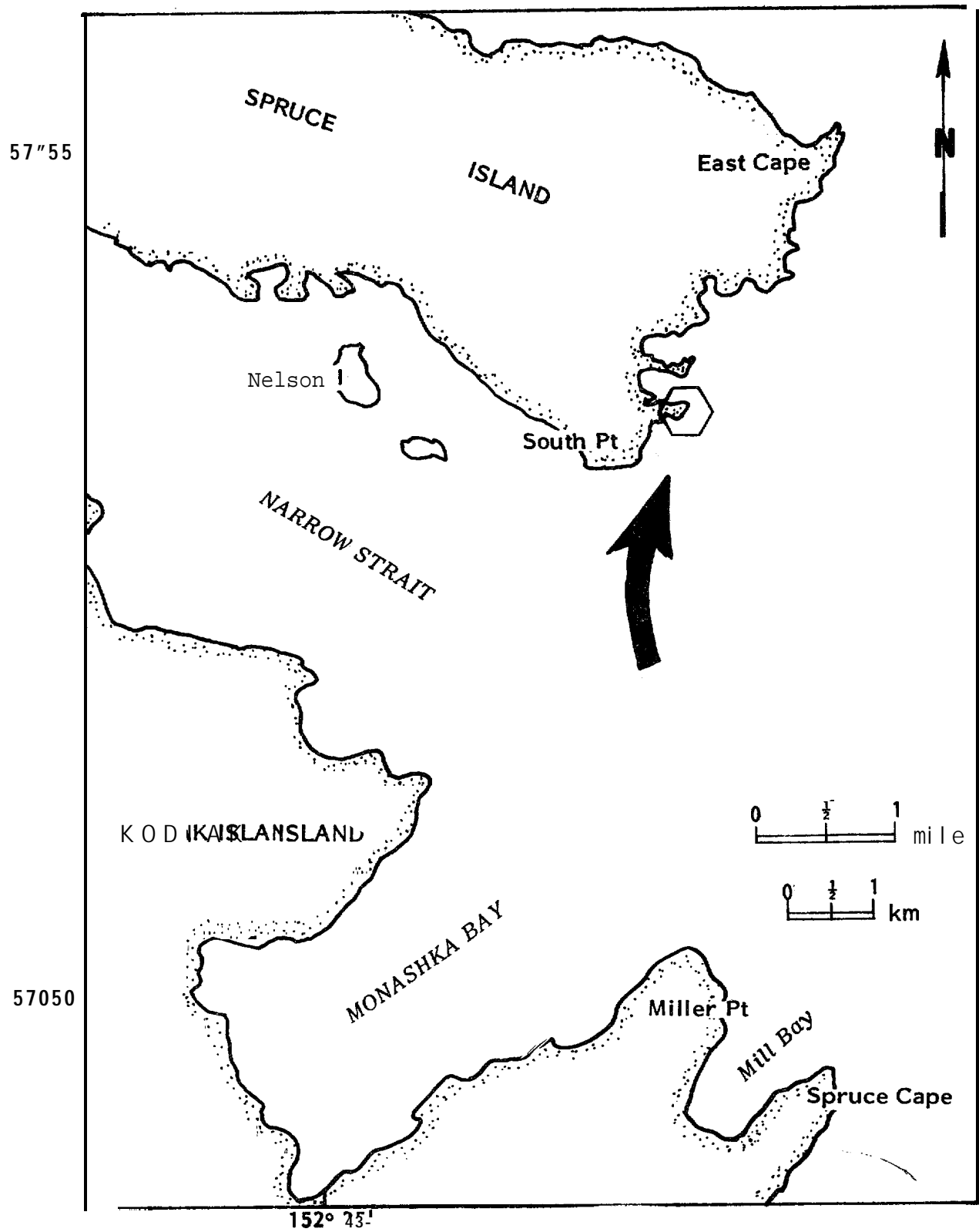


Figure 95. Spruce Island site.



Figure 96. Vertical zonation of intertidal biota
on Spruce Island site.
 Zone 1 = Balanus glandula, Endocladia muricata
 Zone 2 = Fucus cisticchus
 Zone 3 = Odonthalia floccosa, Balanus cariosus
 Zone 4 = Alaria spp.

The rock faces exhibited strong zonation (Figure 96) which seemed relatively consistent throughout the area. The highest intertidal levels contained patchy growths of Endocladia muricata, sterile Fucus distichus, and occasionally very dense Porphyra sp. Balanus glandula were also common in the high areas. The next lower zone contained heavy growths of fertile Fucus and mussels (Mytilus edulis) in addition to B. glandula. Below this was a strong band of Odonthalia floccosa which often overlaid heavy growths of B. cariosus. Finally, the lowest exposed zone was strongly dominated by Alaria sp. whose large blades generally covered a fairly rich collection of encrusting forms such as coralline algae and Halichondria panicea. Katharina tunicata and large B. cariosus were also abundant here.

Zonation and species abundances were similar in the areas of moderately sloping bedrock, although Mytilus appeared to be less common and the alga Rhodomenia palmata appeared to be more abundant. Numbers of large herbivores (urchins) and predators (starfishes, snails) were low throughout the area.

The presence of small tide pools at the fifth site tended to make distribution of biota patchy. Several species such as Odonthalia and Mytilus were generally absent although Odonthalia were common in the pools themselves. On exposed surfaces the fertile Fucus zone appeared to merge directly, without any intermediate zonation, into the area dominated by Alaria. Among the tidepools, pools in the upper intertidal area were generally dominated by Scytosiphon lomentaria; middle-zone pools by Odonthalia, Soranthra sp., and coral line algae; and lower-zone pools by Hedophyllum sessile.

Tonki Bay (Afognak Island)

Tonki Bay is a long (approximately 16 km), narrow bay on the eastern side of Afognak Island (Figure 97). The site we qualitatively sampled in July 1976 lies about halfway down the west side of the bay in an area well protected from waves. The substrate was composed of large boulders overlying a bedrock pavement.

The biota were diverse and dominated by invertebrates. Balanus cariosus was the most common species, and most available space in the intertidal zone seemed to be covered with different age groups of this barnacle. B. cariosus were being heavily preyed upon by Nucella lamellosa and Pisaster ochraceus which were relatively very abundant.

Algae were often patchy and in relatively poor condition. Much of the cover consisted of bladed green algae. Species such as Odonthalia floccosa and Alaria sp. seemed to be competing for space with barnacles and mussels. Often the algae grew on Mytilus edulis and barnacles which covered rock surfaces. In this situation the carnivorous starfishes and drills appeared to have a strong effect as they ate and eroded the invertebrate substrate.

Several zones were evident at Tonki Bay. The highest was dominated by Fucus distichus, Halosaccion glandiforme, Balanus glandula, and Littorina sitkana. A band of mussels was often found just below this, and Nucella lamellosa and polysiphonous red algae were associated with it. There was a zone of red algae below the mussels; this was dominated by Rhodomenia palmata and Odonthalia, and small sea cucumbers and snails (Margarita) were

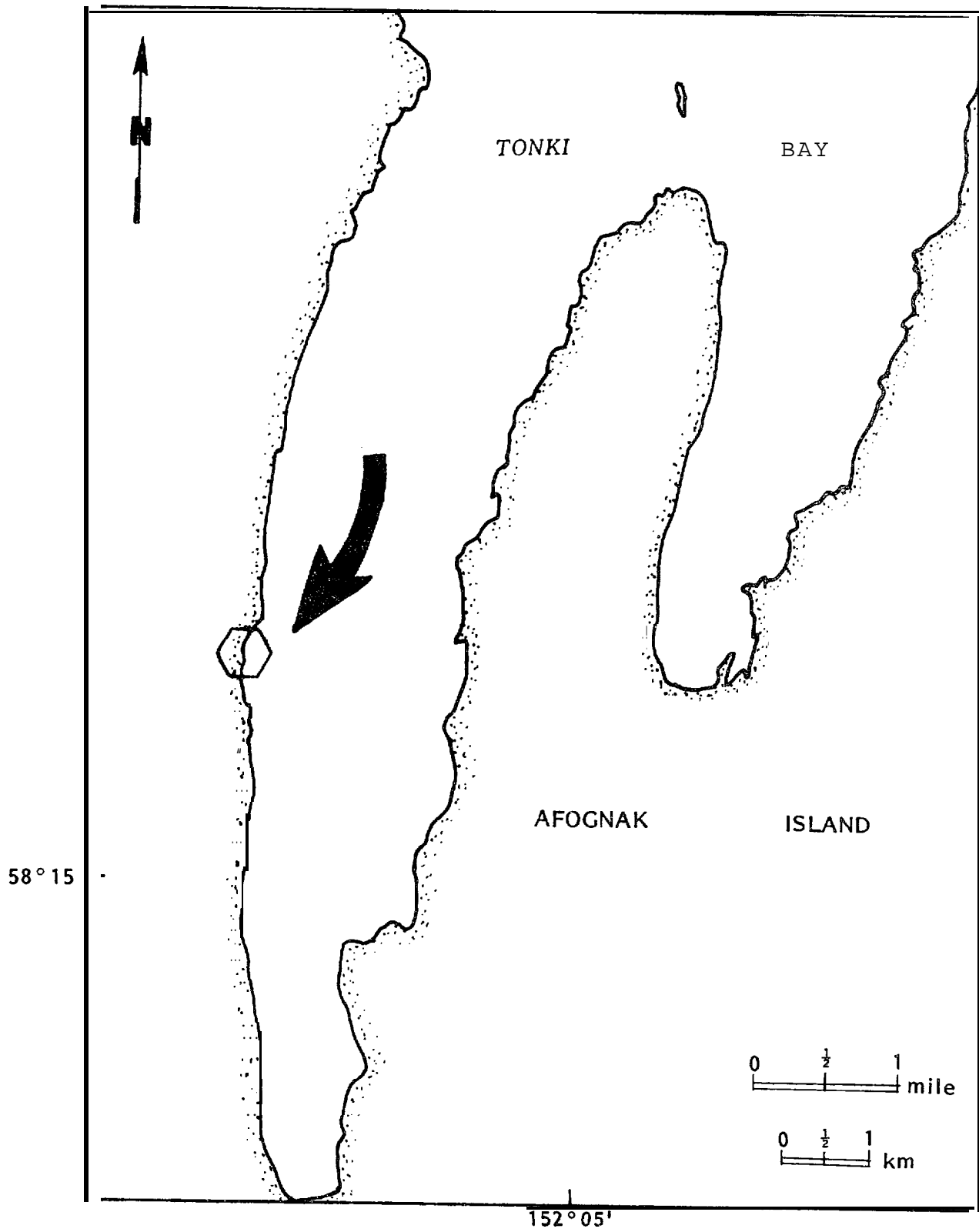


Figure 97. Tonki Bay site,

common invertebrates. The lowest intertidal zone was heavily covered with invertebrates and some Alaria. Common species included bryozoa, Halichondria panicea, B. cariosus, Nucella, and Pisaster. Other species of algae included Gigartina sp. and Iridaea sp.; invertebrates included Fusitriton oregonensis, Pycnopodia helianthoides, Henricia leviuscula, tunicates, and the remains of several urchin tests.

North Shuyak Island

A composite boulder beach in a semi protected location on North Shuyak Island (Figures 98 and 99) was qualitatively sampled in July 1976. Because of topographic changes which had apparently occurred after the 1964 earthquake, it was not possible to pinpoint our location on charts. Thus the location shown in Figure 98 is approximate.

In the lower zones most of the rock surfaces were covered with heavy growths of Alaria sp. whose blades were often covered with Musculus sp. The Alaria occurred over a substory assemblage of bryozoa, Halichondria panicea, Notoacmea scutum, and algae such as Ptilota sp., Gigartina sp., and coral like red forms. Grazing or predatory invertebrates were not immediately apparent. However, when rocks were turned or the many crevices between boulders examined, many Katharina tunicata, Tonicella lineata, and Strongylocentrotus droebachiensis were discovered. Pisaster ochraceus and Pycnopodia helianthoides were discovered in this manner, and two octopuses were also observed under large rocks.

The middle zone was covered with Fucus distichus, Odonthalia floccosa, Balanus cariosus, and Rhodymenia palmata, with numbers of Leptasterias hexactis, limpets, isopods, and amphipods under and between rocks.

In the upper areas small B. glandula and B. cariosus were common along with Littorina sp. Mytilus edulis were found growing among the rocks at some locations.

Whale island

Whale island (Figure 100) lies in the eastern end of Kupreanof Strait between Kodiak and Afognak islands. It is approximately 24 km northwest of the city of Kodiak.

We qualitatively sampled two areas on Whale Island during July 1976. Both were small rock (<2 ft²) and boulder beaches. The first appeared to be located in a highly protected area (although the Coast Pilot reports currents of 4.5 kn in the area). The second appeared to lie in a much more exposed position. Both had a gentle slope without much relief.

In the first area, which lies in Whale Passage on the southwestern shore of the island, we investigated three sites. The first two had large quantities of fresh water running across the beach while the third did not. The presence of fresh water appeared to affect the types of algae present--diatom species and Enteromorpha intestinalis were quite common at sites one and two but less so at site three. Mytilus edulis appeared to be a much more dominant member of the community in areas of freshwater runoff.

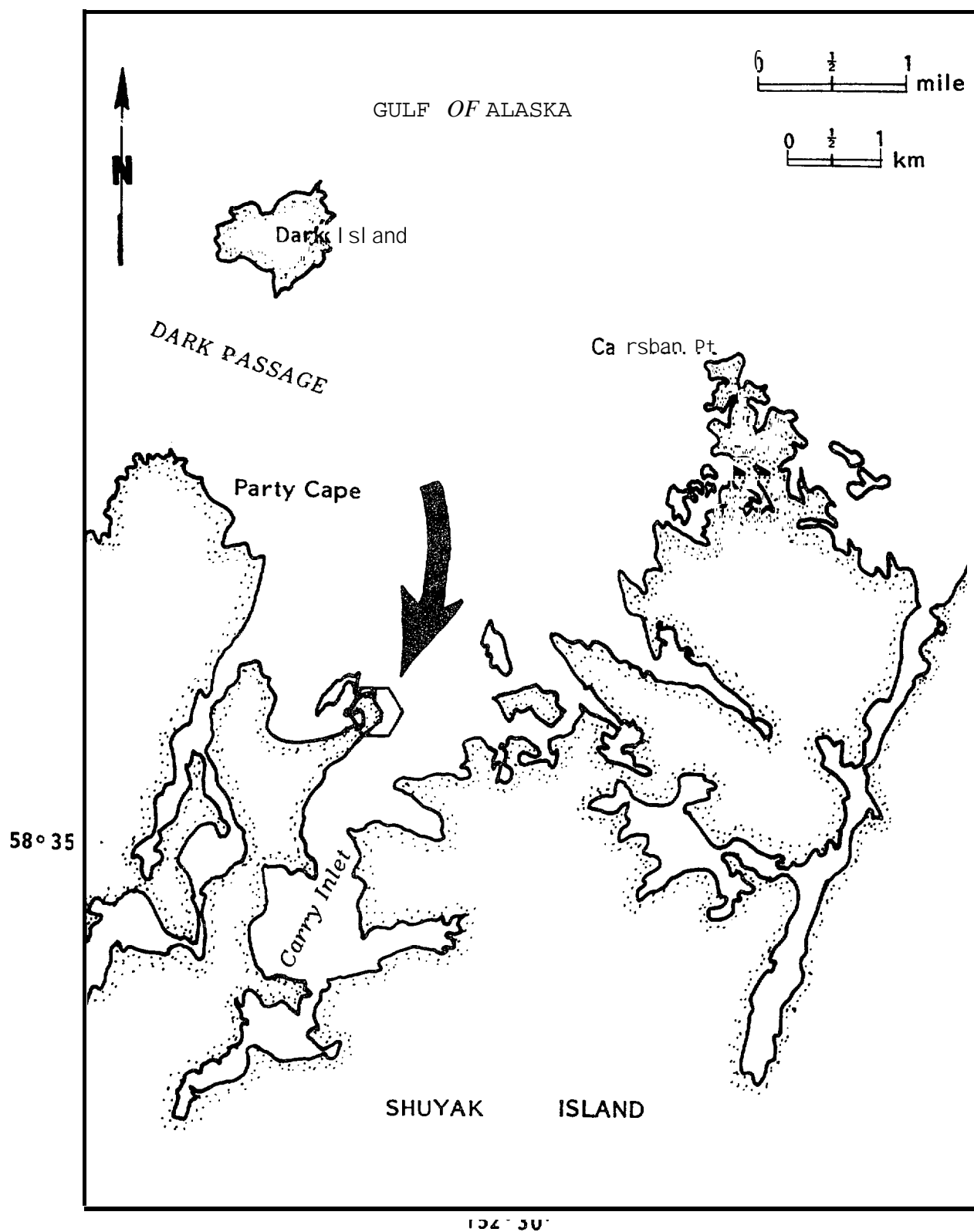


Figure 98. North Shuyak Island site.



Figure 99. North Shuyak Island, July 1976. General view of the sampling area

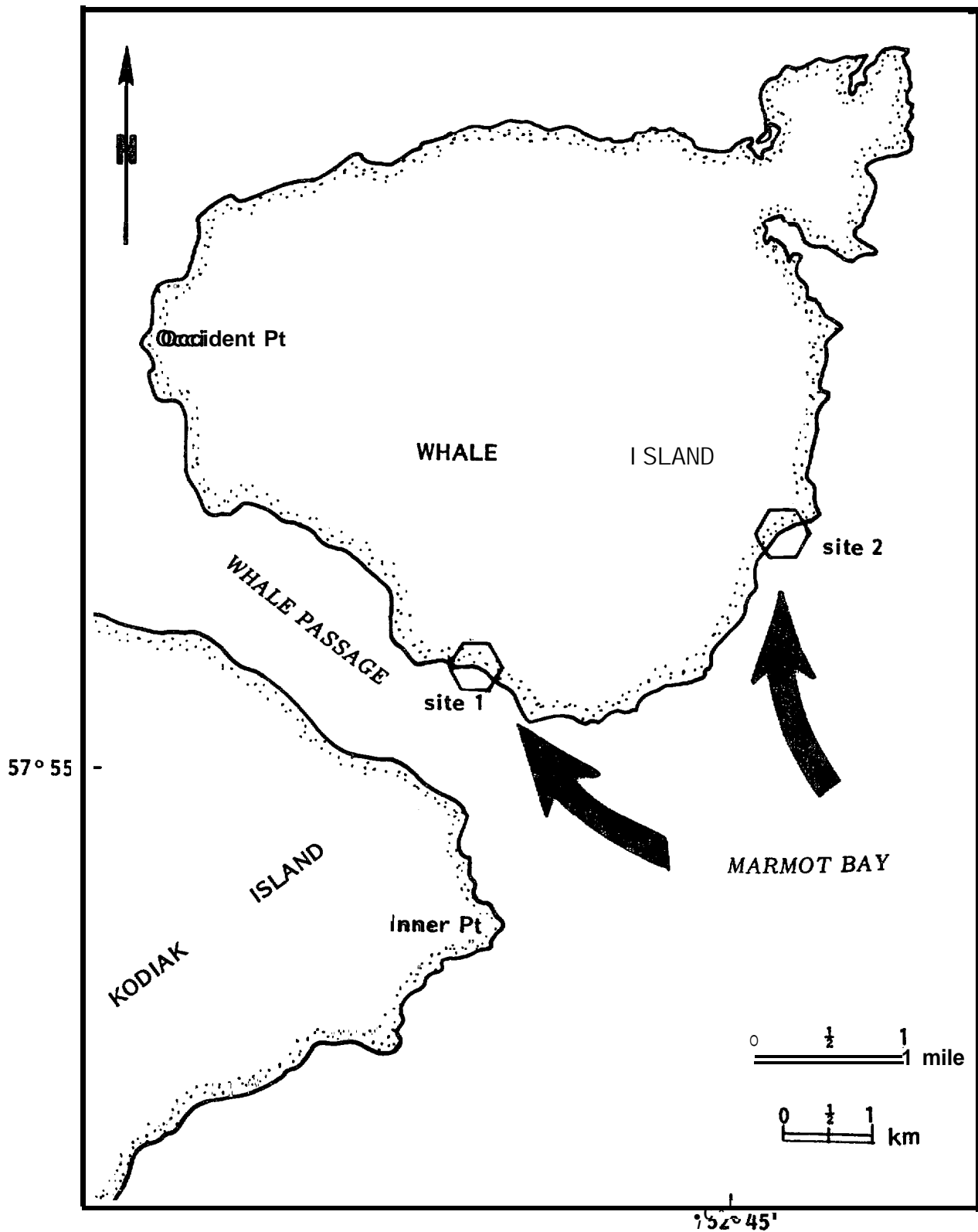


Figure 100. Whale Island sites.

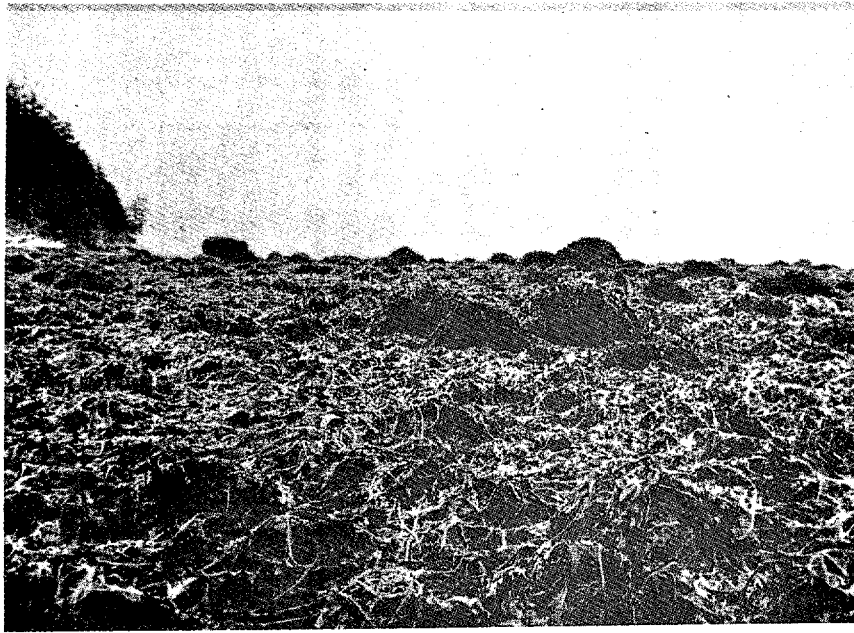


Figure 101. Whale Island, site 1. General view of the area showing heavy intertidal cover attached to small boulders.

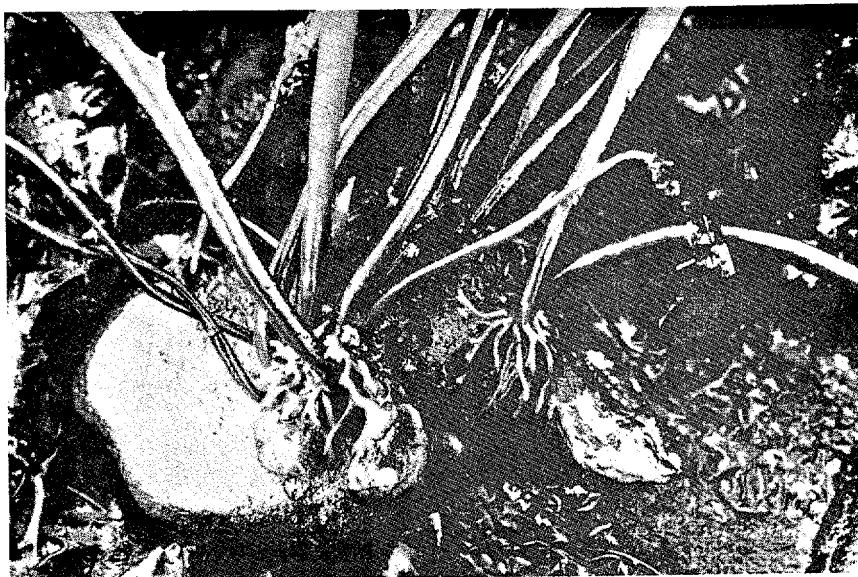


Figure 102. Whale Island, site 1. Alaria holdfasts attached to small boulders.



Figure 103.

Whale Island, site 2.

General view of the area
showing naucity of
intertidal organisms
attached to small boulders.

Figure 104.
Whale Island, site 2.
Barnacles growing in
protected crevices.

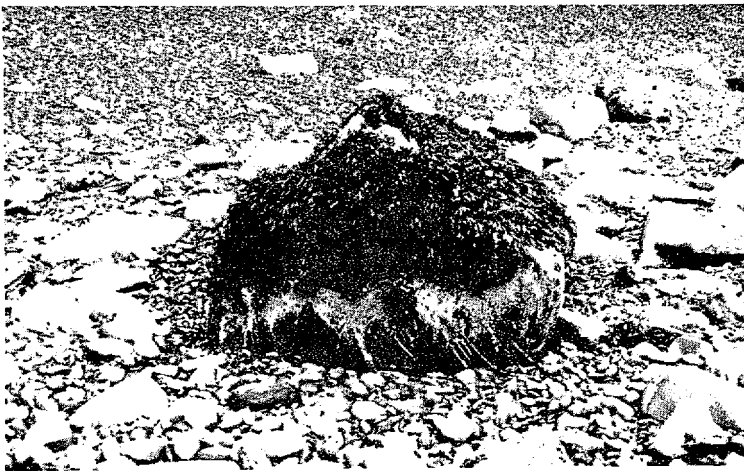
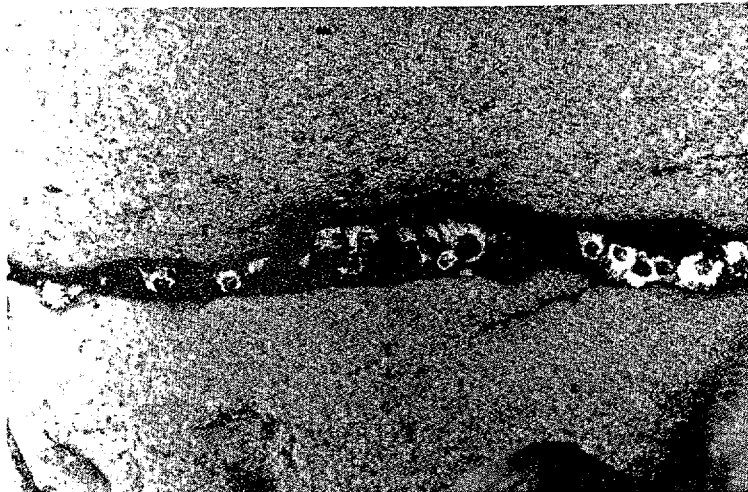


Figure 105.
Whale Island, site 2.
Attached blots was
sparse on abraded
lower surfaces of
large boulders.

In spite of these differences, all three sites had a moderate to heavy cover (Figure 101) of attached biota. The upper areas were dominated by Littorina sitkana and Balanus balanoides. The next lower zone consisted of large clumps of Mytilus which were associated with Odonthalia floccosa and polysiphonous red algae. Predatory snails (Nucella) were active in this zone. Below this was an area dominated by Fucus distichus and Halosaccion glandiforme with associated limpets and small sea cucumbers. These last two zones tended to undulate in relative position--often the Fucus-dominated zone occurred quite high on the beach and extended downward into what was usually the Mytilus-dominated area, while a short distance down the beach Mytilus extended higher than usual.

The lowest exposed area was dominated by the algae Alaria sp. (probably A. marginata), Ulva sp., Rhodomenia palmata, and Hedophyllum sessile. This was a protected habitat as evidenced by large Alaria plants attached to very small rocks (Figure 102). Often two to five plants were attached to a rock only a few inches in diameter. Alaria densities were very high and were associated with a diverse invertebrate community. Common invertebrates, especially in the lowest areas, included Margarita, Pisaster, and an unidentified sedentary polychaete worm which formed large colonies in tide pools. Other species encountered included Pycnopodia helianthoides, Dermasterias sp., Orthasterias sp., Strongylocentrotus droebachiensis, Acmaea mitra, and Tonicella lineata. The starfishes appeared to be feeding on the polychaete colonies. Forms which were rare by comparison with other beaches of the Kodiak Island area included Katharina tunicata and Balanus cariosus.

Seaward of the intertidal area in very shallow water was a large bed of Alaria fistulosa associated with luxuriant growths of Desmarestia sp. and coralline algae.

The second area we explored lies on the more exposed southeastern side of Whale Island. Biota here were much sparser (Figure 103). Almost nothing was attached to the small rock and boulder substrate, possibly because waves had moved the rocks and abraded the attached biota. New sets of barnacles had begun to colonize the area and diatom colonies coated the surfaces of small rocks. On larger boulders, bladed and filamentous green algae grew sparsely. Barnacles and mussels were found in crevices (Figure 104) on the protected areas of very large boulders. The lower exposed surfaces of these large boulders, however, appeared to have been abraded and the rock was bare to a height of about 18 in above the substrate (Figure 105).

Vertical Zonation Patterns of Kodiak Island Area

Two algal species were dominant at almost all intertidal sites. In the middle intertidal area (2-8 ft)*, Fucus distichus were often the most conspicuous organisms. In the lower areas (-2 to +2 ft) at least one species of Alaria was often dominant and several invertebrate species occurred commonly; the barnacle Balanus cariosus was probably the most abundant invertebrate, and its greatest biomass usually occurred at 0 to 4-ft elevations.

* The heights used in this section are generalized in order to indicate areas of relative dominance. Fucus, for instance, was collected from -1.3 ft to +10 ft but tends to produce its greatest biomass in the 2- to 8-ft range.

Several other species also occurred frequently and made major contributions. Those which were found in bands at different elevations have often been separated into descriptive biotic zones. Appropriate reviews of littoral zonation schemes, with emphasis on Alaska, are in Weinmann (1969) and Nybakken (1969).

After comparing our data on vertical distributions with classical concepts of intertidal zonation, it appeared that the Stephenson type system (Stephenson and Stephenson 1972) applies best to the zonation patterns in the Kodiak Island area. This system recognizes three littoral zones: the supralittoral or splash zone; the littoral zone; and the infralittoral fringe or upper sublittoral zone. The three zones are not further subdivided in the Stephenson system because this system is meant to be "universal". Within any littoral area, however, several subzones are usually evident. Some authors elevate these to full zonal status, with the decision usually based on the spatial extent of each subzonal unit.

In the Kodiak Island area we found several subzones at each site. Some of these were dominant at one site and absent at others. The mussel Mytilus edulis, for instance, often formed a dominant band on large rocks in protected areas. In exposed locations, however, it was often either a small part of the Fucus zone or absent entirely,

Based on the most common occurrences at all sites in the Kodiak Island area we have divided the Stephenson littoral zone into several subzones. It should be emphasized, however, that this is done for general descriptive purposes and, as seen in previous sections, not all of these subzones were found at all of the sites. This scheme (Table 7) represents a generalized picture of the vertical distributions of the most dominant organisms we encountered. In addition to this general observational scheme, we also used transect line data to interpret zonation. Quantitative data on the occurrence of each of several common species were grouped by 2-ft tidal elevations* (Table 8). Both presence-absence data and data on the presence of each species in quantities of greater than 20 g wet weight per sample were listed. The latter was done because presence-absence data are often confounded by incidental collections of very small amounts of material outside the normal range of occurrence. The data in Table 8 indicate the general vertical range of occurrence, and possibly of dominance, for several species which were abundant.

Spatial and Temporal Variability in Species Composition

Marine biological communities are complex and variable. The distribution and abundance of species vary in time and space and are influenced by many environmental factors. To describe a community completely or to predict its occurrence requires an understanding of the dynamic interactions of the components and a knowledge of temporal and spatial variability.

Most of our knowledge of the intertidal communities in the vicinity of Kodiak Island comes from data collected at a few geographic locations which were often sampled only once or twice. This approach is adequate to describe gross characteristics of communities and has been used in this and other surveys.

* Data from all large boulder and bedrock sites were used. Dolina Point and Low Cape data were not included because 1/16-m² quadrats were not used.

Table 7. --Generalized zonation of rocky intertidal areas of the Kodiak Island area.

Zone	Approximate tidal range	Biological name	Characteristic organisms
Zone 1-Supralittoral Fringe	Highest reach of spray to mean higher high water	<u>Porphyra-Prasiola</u> zone = <u>Littorina</u> zone (Stephenson and Stephenson 1972, p 20) = <u>Littorina-Verrucaria</u> zone (Lewis 1964, p 82)	<u>Prasiola meridionalis</u> , <u>Porphyra</u> sp., <u>Littorina sitkana</u>

Zone 2--Littoral Zone	Mean higher high water to low water of spring tides	<u>Barnacle-Endocladia</u> zone = Barnacle zone (Nybakken 1969, p 75) = Upper Barnacle zone (Lewis 1964)	<u>Littorina sitkana</u> , <u>Chthamalus dalli</u> , <u>Balanus glandula</u> , <u>Acmaea digitalis</u> , Diatom colonies, <u>Collisella pelta</u> , <u>Endocladia muricata</u> , sterile <u>Fucus distichus</u>
Subzone 2A			
Subzone 2B		<u>Fucus</u> zone = <u>Fucus</u> zone (Nybakken 1969, p 123) = <u>Fucus</u> zone (Stephenson & Stephenson 1972) = <u>Balanus</u> , <u>Patella</u> , <u>Fucus</u> zone (Lewis 1964, p 82) = upper mid-littoral zone (Kozloff 1973, p 124)	Fertile <u>Fucus distichus</u> , <u>Mytilus edulis</u> , <u>Nucella lima</u> , <u>N. lamellosa</u> , <u>Odonthalia floccosa</u>
Subzone 2C		<u>Rhodomenia</u> zone = red algae belt (Lewis 1964, p 82) = Rhodophyceae zone (Lewis 1964, p 78)	<u>Rhodomenia palmata</u> , <u>Ulva-Monostroma</u> , <u>Balanus cariosus</u> , <u>Cucumaria pseudocurata</u>
Subzone 2D		<u>Alaria</u> zone = <u>Alaria</u> zone (Weinmann 1969, p 29)	<u>Alaria</u> spp., <u>Lithothamnion</u> sp., <u>Ptilota filicina</u> , <u>Crisis</u> , <u>Halichondria panicea</u> , <u>Katharina tunicata</u>

Zone 3-Infralittoral Fringe	Low waters of spring tides to true subtidal (below lowest low water)	<u>Laminaria</u> zone	<u>Laminaria longipes</u> , <u>Laminaria dentigera</u> , <u>Lithothamnion</u> sp., <u>Corallina</u> sp., <u>Acmaea mitra</u>

Table 8---Percent of samples in which common species occurred and percent of samples with more than 20 g wet weight of each species in 1/16 m² quadrat samples collected at different tidal elevations on boulder and bedrock in intertidal sites in the Kodiak Island area.

Species		Elevation (ft) and number of samples collected								
		<-2 (2)	-2-0 (47)	0-2 (122)	2-4 (115)	4-6 (64)	6-8 (39)	8-10 (11)	10-12 (4)	12-14 (1)
<u>Littorina sitkana</u>	% of samples	0	23	51	60	84	97	100	100	0
	% with more than 20 g	0	0	0	2	13	36	0	25	0
<u>Balanus glandula</u>	% of samples	0	0	3	15	28	46	27	75	0
	% with more than 20 g	0	0	0	7	11	8	9	25	0
<u>Fucus distichus</u>	% of samples	0	17	34	47	63	82	45	25	0
	% with more than 20 g	0	2	12	30	31	56	27	0	0
<u>Collisella pelta</u>	% of samples	0	6	20	36	41	46	0	25	0
	% with more than 20 g	0	0	0	0	0	0	0	0	0
<u>Mytilus edulis</u>	% of samples	0	9	16	27	41	31	9	0	0
	% with more than 20 g	0	0	0	4	14	10	0	0	0
<u>Nucella lima</u>	% of samples	0	4	5	10	19	5	0	0	0
	% with more than 20 g	0	0	1	1	6	0	0	0	0
<u>Rhodomenia palmata</u>	% of samples	50	40	39	31	23	15	9	0	0
	% with more than 20 g	0	2	11	20	13	0	0	0	0
<u>Polysiphonous red algae</u>	% of samples	0	9	15	10	15	9	9	0	0
	% with more than 20 g	0	4	2	7	0	0	0	0	0
<u>Odonthalia floccosa</u>	% of samples	0	45	54	28	34	44	0	0	0
	% with more than 20 g	0	13	27	16	17	18	0	0	0
<u>Balanus cariosus</u>	% of samples	0	23	26	21	28	15	9	0	0
	% with more than 20 g	0	9	17	15	11	8	0	0	0

Table 8.--Continued.

Species		Elevation (ft) and number of samples collected								
		<-2 (2)	-2-0 (47)	0-2 (122)	2-4 (115)	4-6 (64)	6-8 (39)	8-10 (11)	10-12 (4)	12-14 (1)
<u>Holothurians</u>	% of samples	0	51	77	32	23	13'	6	0	0
	% with more than 20 g	0	0	2	2	0	0	0	0	0
<u>Halosaccion glandiforme</u>	% of samples	0	9	34	21	27	8	0	0	0
	% with more than 20 g	0	0	16	4	6	0	0	0	0
<u>Margaritas</u> sp.	% of samples	0	53	62	12	11	10	0	0	0
	% with more than 20 g	0	0	0	0	2	0	0	0	0
<u>Ulva</u> les	% of samples	0	21	42	32	20	3	9	0	0
	% with more than 20 g	0	0	8	9	0	0	0	0	0
<u>Halichondria panicea</u>	% of samples	50	30	33	19	8	5	0	0	0
	% with more than 20 g	0	13	16	3	0	0	0	0	0
<u>Rhodomela larix</u>	% of samples	0	17	9	13	8	5	0	0	0
	% with more than 20 g	0	11	9	10	5	0	0	0	0
<u>Gigartina</u> sp.	% of samples	0	9	21	8	8	8	0	0	0
	% with more than 20 g	0	4	1	2	3	0	0	0	0
<u>Katharina tunicata</u>	% of samples	50	32	17	10	2	0	0	0	0
	% with more than 20 g	0	11	11	6	0	0	0	0	0
<u>Alaria</u> sp.	% of samples	50	64	61	20	6	8	9	0	0
	% with more than 20 g	50	33	47	9	2	0	0	0	0

However, because communities exhibit spatial and temporal differences in numbers and abundance of species (Krebs 1972, Pianka 1974), it is impossible to describe a community completely by sampling it only once. There is also no information on feeding, growth, movement, fecundity, and mortality of organisms present.

To gain information on the spatial and seasonal variability that may exist in our study locations, we compared data collected for this purpose from sites visited more than once and from sites where replicate transect lines were used. To determine whether the degree of exposure and type of substrate are correlated with specific biological communities in the Kodiak Island area, we compared data between several study sites.

Spatial Variability

To learn of spatial variability in the Kodiak Island area, we compared replicate data from Cape Kaguyak and Sud Island. At both sites we collected samples simultaneously along two adjacent transect lines.

The two adjacent transect lines sampled in May 1976 at Cape Kaguyak contained a total of 74 species, 42 of which were common to both lines (Table 9). Transect line 1 contained 64 species (86% of the total) while transect line 2 contained 52 species (only 70% of the total). Some common rocky intertidal species present in transect line 1 but missing from transect line 2 were Katharina tunicata, Halosaccion glandiforme, and Laminaria spp. ; species present in transect line 2 but missing from transect line 1 were Balanus glandula and Lridaea cornucopia. None of the species missing from one line were dominant in the other.

The two adjacent transect lines sampled in August 1975 at Sud Island contained a total of 211 species, 116 of which were common to both lines (Table 9). Transect line 2 contained 171 species (81% of the total), while transect line 1 contained 156 species (only 74% of the total). Some common rocky intertidal species present in transect line 2 but missing from transect line 1 were Balanus glandula, Mytilus edulis, Knódoméla larix, and Alaria sp. ; species present in transect line 1 but missing from transect line 2 were Chthamalus dalli and Laminaria yezoensis. With the possible exception of B. glandula, no dominant species was missed by either transect line. Depending on which line and location were chosen, 14% to 30% of the species known to be present were missed when only one line was considered at each location sampled. Thus, it is apparent that a significant number of species present can remain undetected when an area is sampled by only one transect line. It is also apparent that of the possible habitats present, i.e. , outer surfaces of rocks, cracks, crevices, channels and tide pools, and under surfaces of rock, the outer rock surfaces were sampled most often by our transect sampling techniques. Therefore, sessile species characteristic of outer rock surfaces were well represented in our transect line samples, while motile and more hidden species (cryptofauna of Lewis [1964]) characteristic of the other habitat types mentioned were found seldom or not at all.

As could reasonably be expected, differences were also observed in biomass (mean wet weight per square meter) between adjacent transect lines for the 16 most dominant species (Table 10). A marked difference in mean biomass between the two transect lines occurred for 10 of the 16 dominant species at Cape Kaguyak and 12 of the 16 species at Sud Island.

Table 9. Spatial and temporal **variability in total** numbers of species* from transect lines sampled at Cape **Kaguyak** and Sud Island.

	<u>Spatial variability</u>		
	<u>Cape Kaguyak, two adjacent transect lines, 1976</u>		
	<u>Line 1</u>	<u>Line 2</u>	<u>Lines 1 and 2</u>
Total species	64	52	74
Common species	42	42	42
% Missing	14	30	--

	<u>Spatial variability</u>		
	<u>Sud Island, two adjacent transect lines, 1975</u>		
	<u>Line 1</u>	<u>Line 2</u>	<u>Lines 1 and 2</u>
Total species	156	171	211
Common species	116	116	116
% Missing	26	19	---

	<u>Temporal variability</u>		
	<u>Sud Island, transect line 1, May and August 1975</u>		
	<u>May</u>	<u>August</u>	<u>May and August</u>
Total species	133	156	208
Common species	87	87	87
% Missing	36	25	---

* Includes marine **algae**, sea grasses, invertebrates (including **insects**), fishes, and fish eggs.

Temporal Variability

Seasonal differences in species composition and abundance have been difficult to document. One of the major problems is that data from different seasons were collected along different transect lines and therefore we are unable to differentiate between seasonal effects and differences in species composition between lines. For example, at Sud Island in August there were 84 species which were not found in May. The total for both dates was 208 species, 87 of which were common to both months (Table 9). The August sample contained 156 species (75% of the total) while the May sample had 133 species (64% of the total). Some common rocky intertidal species present in August but missing in May were Katharina tunicata, Chthamalus dalli, Mytilus edulis, and Leptasterias hexactis. Some common rocky intertidal species present in May but missing on at least one of the August transects were Balanus glandula, Spongomorpha spp., and Nucella sp. Some of these differences are shown in Table 10. None of the species missing from the one month's sample were dominant in the other. The large size of individuals of additional species present in the August samples indicates that they were present in May but not along the transect line sampled. Therefore the differences in species composition reflect spatial rather than seasonal variability.

Differences were also observed between May and August samples in biomass for the 16 most dominant organisms (Table 10). For example, at Sud Island seven species had lower biomass in August, four species had higher biomass in August, and five showed no major differences in biomass between May and August. Because most species showed a decrease in biomass during this time, rather than an increase due to seasonal growth, these differences also probably reflect spatial rather than seasonal variability.

Relation of Species Composition and Abundance to Habitat

Although exposure to waves is difficult to quantify (Bascom 1964), it and substrate type are often used to characterize intertidal communities (Lewis 1964, Rickets and Calvin 1968, Dayton 1973) because they are easily described and because organisms have tolerances or preferences for both factors. However, other factors such as predation, competition, tidal exposure, temperature, light, salinity, turbidity, and humidity also greatly influence community composition (Paine 1966, Paine and Vadas 1969, Connell 1970, Dayton 1971, Estes and Palmisano 1974). Because we did not measure these factors, our analysis of relationships between community distribution and habitat types depends on correlating the habitat factors of substrate type, vertical relief, and wave exposure. It should be emphasized, therefore, that the results of this analysis are preliminary, simplistic, and probably incomplete. This is especially true because correlation is not proof of cause and may even be misleading in areas of limited data.

Data Based on Quantitative Collections

To make the comparison between species occurrences and habitat, we ranked (from most to least dense) the biomass along transect lines, of 16 dominant organisms from nine rocky beach sites and tested them against gradients of wave exposure and topography (Table 11). Exposure and topography ranged from sheltered, sloping areas which usually had much relief in the form of

Table 10. --Mean biomass (wet weight in grams per square meter) of 16 dominant organisms from 1/16m² quadrats along transect lines sampled at Sud Island and Cape Kaguyak.

Dominant organism	Sud Island 1975			Cape Kaguyak 1976	
	May	August		May	
	Transect 1	Transect 1	Transect 2	Transect 1	Transect 2
<u>Littorina</u>	505.4	286.1	184.2	25	147
<u>Mytilus</u>	0	0	55.5	0	0.2
<u>Fucus</u>	1375.7\$'''	1098.6?	816.9§	917¶	594**
<u>Odonthalia</u>	0.5	3.8	23.1	0	0.5
<u>Rhodomenia</u>	642.9	501.1	703.1	77	170
<u>Alaria</u>	1842.1	598.2	96.0	1272	2271
Porifera	115.3	177.3	25.6	3.2	332
<u>Rhodomela</u>	0	0	0.1	0	0
<u>Laminaria</u>	124.4	0	379	112	0
<u>Katharina</u>	0	4.1	24.8	37	0
<u>Ulvaes</u>	11.4	1.5	0.0	70.6	62.4
<u>Spongomorpha</u>	62.4	0	3.6	6	112
<u>Balanus cariosus</u>	177.4	5.5	382.5	69	2.9
<u>Collisella pelta</u>	14.1	2.9	4.5	0.8	0
<u>Phyllospadix</u>	0	0	0	0	0
<u>Halosaccion</u>	1.1	0.4	65.2	8	0

* from 9 of 15 quadrats † from 8 of 15 quadrats

§ from 12 of 27 quadrats ¶ from 4 of 8 quadrats

** from 3 of 7 quadrats

Table 11. --Ranked order (from 1, most dense, to 10, least dense) of biomass (mean wet weight in grams per square meter) for 16 dominant organisms along transect lines at nine rocky beach sites in the Kodiak Island area, 1975 and 1976. Sites are arranged, left to right, from partly protected, nonflat sites to exposed, flat sites.

Organism	Partly Protected				Exposed					
	Nonflat				Nonflat		Flat			
	Small boulders		Large boulders		Large boulders		Small boulders		Small boulders	
	Bedrock Three Bay	St. Point #3	Lagoon Point #1,2	Large boulders Cape Kaguyak	Bedrock Sundstrom Island	Lagoon Sud Island	Bedrock Chirikof Island	Dolina Point	Bedrock Cape Sitkinak	Small boulders Low Cape
<u>Spongomorpha</u>	3	4	1	2	6	5	9	7	9	9
<u>Rhodymenia</u>	6	5	3	4	2	1	8	7	9	10
<u>Katharina</u>	1	4	3	5	2	6	9	7	8	10
<u>Alaria</u>	3	1	2	4	7	6	5	8	9.5	9.5
<u>Laminaria</u>	8	1	3	6	2	4	7	5	10	9
<u>Balanus cariosus</u>	1	6	2	8	3	5	10	4	9	7
Porifera	1	6	8	3	2	7	5	4	10	9
<u>Mytilus</u>	1	10	2		3	5	9	6	8	4
<u>Halosaccion</u>	7	5	2	6	4	3	1	9.5	8	9.5
Ulvaes	8	1	3	4	5	7	6	2	9.5	9.5
<u>Fucus</u>	7	10	5	2	4	1	3	6	8	9

Table 11. --Continued.

Organism	Partly Protected					Exposed				
	Nonflat				Nonflat		Flat			
	Small boulders		Large boulders		Large boulders		Small boulders		Small boulders	
	Bedrock Three Bay	St. Point #3	Lagoon Point #1,2	Large boulders Cape Kaguyak	Bedrock Sundstrom Island	Large boulders Sud Island	Bedrock Chirikof Island	Dolina Point		Bedrock Cape Sitkinak
<u>Littorina</u>	5	10	9	3	2	1	4	8	6	7
<u>Odonthalia</u>	3	6	5	10	2	9	1	4	7	8
<u>Collisella pelta</u>	2	9	10	7	4	5	6	1	3	8
<u>Rhodomela</u>	8.5	8.5	8.5	8.5	5	6	4	2	1	3
<u>Phyllospadix</u>	7.5	7.5	7.5	7.5	1	7.5	4	2	3	7.5
All species*	4	5	†	6	2	1	3	7	9	8
All plant species*	4	5	†	7	3	1	2	6	8	9
All invertebrate species*	5	5	†	6	1	2	4	8	9	7

* Includes all species sampled and not only those listed above.

† Lagoon Point data were pooled

hummocks, surge channels, or large boulders, to exposed, flat areas which usually had little relief and were often covered with tide pools and standing water. Although no significant relationships were noted between biomass and habitat type for algal or invertebrate groups, biomass did tend to vary along these gradients for many individual species (Table 11). A Mann-Whitney test (Conover 1971) showed these trends to be significant ($p < 0.05$) for five genera. The biomass of Spongomorpha and Alaria was greater per square meter along transect lines in partly protected and nonflat areas than in exposed and flat areas, the biomass of Rhodymenia and Katharina was also greater in nonflat areas than in flat areas, and the biomass of Rhodomela was greater in exposed and flat areas than in partly protected and nonflat areas. No significant differences ($p > 0.05$) were noted in biomass between boulder areas and nonflat bedrock areas for any species or group of species.

Similar analyses between species richness (number of species) and habitat type (Tables 12 and 13) showed no significant relationships ($p > 0.05$). However, the highest species richness for both algae and invertebrates occurred along transect lines at exposed, nonflat, bedrock and boulder sites while the lowest species richness for these groups occurred at exposed, flat, bedrock sites.

Finally, the nine rocky sites were categorized according to habitat--exposure (partly protected, exposed), vertical relief (flat, non-flat), and substrate (boulders, bedrock)--and the habitat categories were tested against the average biomass per sample (wet weight in grams per square meter) of the same 16 organisms at each site (Table 14). Four of the organisms showed consistent relationships to habitat: Katharina, Rhodomela, Rhodymenia, and Spongomorpha. In each case, the most definite relationship was to vertical relief (flat vs. nonflat), with Rhodomela being found in exposed, flat habitats while the other three were more common in nonflat habitats.

Cover Estimates

Because the transect line collection method was not always representative of all habitats present, we also estimated the percent of cover of dominant species, usually macrophytes, in quadrats along several additional transect lines. Earlier studies (Zimmerman 1975) had indicated that, for most species, percent cover is highly correlated with biomass.

Data from these estimates (Table 15) are similar to the quantitative sampling data. Again, Rhodomela was most common at flat, exposed sites. Gigartina, a species not found in quantitative collections, was also dominant at flat, exposed sites. Alaria and Rhodymenia were most common on the nonflat beaches.

Qualitative Observations with Emphasis on the July 1976 Survey

The purpose of qualitatively observing several different habitats was to discern general trends which might have been overlooked due to the inherent limitations of transect lines and "to provide additional observations to verify trends observed during previous work. Some of the major trends are discussed below.

Table 12. --lb.unber of species identified in each major taxonomic group from transect lines sampled at nine rocky beach sites in the Kodiak Island area, 1975 and 1976.

Taxonomic group	Partly Protected					Exposed				
	Nonflat				Nonflat			Flat		
	Small boulders		Large boulders		Large boulders		Small boulders		Small boulders	
	Bedrock Three Bay	St. Point #3	Lagoon Point #1,2	Lagoon Cape Kaguyak	Bedrock Sundstrom Island	Large boulders Sud Island	Bedrock Chirikof Island	Dolina Point	Bedrock Cape Sitkinak	Small boulders Low Cape
Chlorophyta	9	7	*	3	9	9	9	2	1	0
Phaeophyta	7	10	*	6	15	18	23	5	3	2
Rhodophyta	25	18	*	14	34	41	33	22	17	12
Porifera†	1	1	*	1	1	1	1	1	1	1
Onidaria†	3	2	*	1	1	2	1	1	1	1
Turbellaria†	1	1	*	1	1	1	1	1	1	1
Rhynchocoela†	1	1	*	1	1	1	1	1	1	1
Nematoda†	1	1	*	1	1	1	1	0	0	1
Annelida§	44	4†	*	1†	57	56	43	1†	1†	1†
Polyplacophora	5	3	*	2	7	3	2	1	0	1
Pelecypoda	6	6	*	5	9	7	7	6	1	5
Gastropoda	22	30	*	16	29	22	18	14	11	14
Arachnida†	1	1	*	1	1	1	1	0	0	0

Table 12. --Continued.

Taxonomic group	Partly Protected				Exposed					
	Nonflat				Nonflat			Flat		
	Bedrock	Small boulders	Large boulders	Large boulders	Bedrock	Large boulders	Bedrock	Small boulders	Bedrock	Small boulders
	Three St. Bay	Lagoon Point #3	Lagoon Point #1,2	Cape Kaguyak	Sundstrom Island	Sud Island	Chirikof Island	Dolina Point	Cape Sitkinak	Low Cape
Pycnogonida†	1	0	✱	2	2	2	2	1	3	2
Crustacea§	23	15†	✱	10†	20	26	23	9†	9†	14†
Bryozoa†	1	1	*	1	3	3	1	0	0	0
Asteroidea	1	1	*	2	3	1	2	1	1	2
Ophiuroidea	1	1	*	1	2	1	1	0	0	0
Holothuroidea	1	2	*	1	0	2	1	1	1	1
Echinoidea	1	1	*	0	0	0	0	0	0	0
Total species¶	155	106	*	70	196	198	171	66	52	59
Plant species¶	41	35	✱	23	58	68	65	29	21	14
Invertebrate species¶	114	71	✱	47	138	130	106	37	31	45

* All Lagoon Point data were pooled.

† Organisms not identified to species level at all sites.

§ Most organisms not identified to species.

¶ Includes all species collected, not only those in the above groups.

Table 13. --Ranked order (from 1, most dense, to 9, least dense) of species richness (numbers of species) in selected **taxonomic** groups (those with the "**easiest**" species to identify) from transect lines at nine rocky beach sites in the Kodiak Island area, 1975 and 1976. Sites are arranged, **left** to right, from **partly** protected, nonflat sites to exposed, flat sites.

Taxonomic group	Partly Protected				Exposed					
	Nonflat				Nonflat		Flat			
	Smal 1 boulders		Large boulders		Large boulders		Small boulders		Small boulders	
	Bedrock Three St. Bay	Lagoon Point #3	Lagoon Point #1,2	Large boulders Cape Kaguyak	Bedrock Sundstrom Island	Lagoon Sud Island	Bedrock Chirikof Island	Dolina Point	Bedrock Cape Sitkinak	Small boulders Low Cape
Chlorophyta	2.5	5	*	6	2.5	2.5	2.5	7	8	9
Phaeophyta	5	4	*	6	3	2	1	7	8	9
Rhodophyta	4	6	*	8	2	1	3	5	7	9
Annelida†	3	5§	*	7.5\$	1	2	4	7.5\$	7.5\$	7.55
Polyplacophora	2	3.5	*	5.5	1	3.5	5.5	7.5	9	7.5
Pelecypoda	5	5	*	7.5	1	2.5	2.5	5	9	7.5
Gastropoda	3.5	1	*	6	2	3.5	5	7.5	9	7.5
Crustacea†	2.5	5§	*	7§	4	1	2.5	8.5\$	8.5\$	6§
Total species¶	4	5	*	6	2	1	3	7	9	8
Plant species¶	4	5	*	7	3	1	2	6	8	9
Invertebrate species¶	3	5	*	6	1	2	4	8	9	7

* Lagoon Point data were Pooled.

† Organisms not identified to species at all sites.

§ Most organisms not identified to species.

¶ Includes all species collected, not only those in the above groups.

Table 14---Average biomass (wet weight in grams per square meter) of 16 organisms along transect lines at nine rocky beach sites in the Kodiak Island area, 1975 and 1976.

Taxonomic group	Partly Protected					Exposed				
	Nonflat				Nonflat		Flat			
	<u>Bedrock</u>	<u>boulders</u>	<u>boulders</u>	<u>boulders</u>	<u>Bedrock</u>	<u>boulders</u>	<u>Bedrock</u>	<u>boulders</u>	<u>Bedrock</u>	<u>Small</u>
	<u>Three St.</u>	<u>Lagoon</u>	<u>Lagoon</u>	<u>Cape</u>	<u>Sundstrom</u>	<u>Sud</u>	<u>Chirikof</u>	<u>Dolina</u>	<u>Cape</u>	<u>boulders</u>
	<u>Bay</u>	<u>#3</u>	<u>#1,2</u>	<u>Kaguyak</u>	<u>Island</u>	<u>Island</u>	<u>Island</u>	<u>Point</u>	<u>Sitkinak</u>	<u>Low Cape</u>
<u>Spongomorpha</u>	46.67	23.11	119.65	55.57	9.52	17.06	0.00	1.13	0.00	0.00
<u>Rhodymenia</u>	26.91	69.89	297.02	120.53	409.41	634.78	2.30	7.03	0.80	0.00
<u>Katharina</u>	714.45	27.02	88.75	19.95	249.43	13.24	0.00	0.00	0.00	0.00
<u>Alaria</u>	2,977.60	4,801.42	3,016.55	1,738.24	578.90	656.85	1,209.68	200.00	0.00	0.00
<u>Laminaria</u>	6.91	1,820.62	1,123.80	59.73	1,253.52	216.11	11.85	72.97	0.00	0.21
<u>Ba lanus</u>	12,210.70	189.51	1,036.30	38.51	898.88	232.25	0.12	321.72	1.75	105.34
<u>cariosus</u>										
<u>Porifera</u>	1,536.34	97.78	28.20	157.01	511.04	87.84	149.12	152.20	0.00	1.54
<u>Mytilus</u>	1,299.76	0.00	1,007.35	0.11	33.21	27.20	0.00	0.71	0.00	20.15
<u>Halosaccion</u>	2.11	50.22	16.68	10.13	23.78	32.30	56.02	0.00	1.82	0.00
<u>Ulvaes</u>	1.72	156.80	77.60	66.78	57.34	3.20	32.47	133.40	0.00	0.00
<u>Fucus</u>	30.06	0.00	278.85	766.93	588.17	1,028.45	671.19	184.84	11.71	0.39
<u>Littorina</u>	15.26	0.53	6.45	82.56	11.20	7.16	147.73	68.45	11.20	10.66
<u>Odonthalia</u>	182.79	124.09	138.45	0.21	917.24	12.43	1,023.71	178.19	86.62	56.61
<u>Collisella</u>	11.61	0.00	0.00	0.43	10.88	6.45	4.06	13.46	11.56	0.18
<u>pelta</u>										
<u>Rhodomela</u>	0.00	0.00	0.00	0.00	43.88	0.07	113.87	289.30	782.33	197.07
<u>Phyllospadix</u>	0.00	0.00	0.00	0.00	512.06	0.00	0.00	65.56	21.24	0.00

Table 15. --Plants and Bryozoa ranked by estimates of percent cover at rocky beach sites in the Kodiak Island area, May 1976. Asterisk indicates dominance and/or consistency.

Tidal elevation (ft)	Nonflat					
	Boulders (Cape Kaguyak)			Boulders (Lagoon Point)"		
	Transect 1	Transect 2	Transect 3	Transect 1	Transect 2	Transect 3
-2.0 to 0.0	<u>*Alaria</u> <u>Ulva-Monostroma</u> <u>Laminaria</u> <u>Coralline algae</u>	<u>*Iridea</u> <u>Alaria</u> <u>Coralline algae</u>	no observation	<u>*Alaria</u> <u>Bryozoa</u> <u>Laminaria</u> <u>Lithothamnion</u>	<u>*Alaria</u> <u>Lithothamnion</u> <u>Bryozoa</u>	<u>*Alaria</u> <u>Ondonthalia</u> <u>Lithothamnion</u> <u>Bryozoa</u>
0.1 to 2.0	<u>*Alaria</u> <u>*Rhodymenia</u> <u>Iridea</u> <u>Spongomorpha</u>	<u>*Alaria</u> <u>*Rhodymenia</u> <u>Spongomorpha</u> <u>Ulva-Monostroma</u>	<u>Fucus</u> (1 observation)	<u>*Alaria</u> <u>Rhodymenia</u> <u>Ulva-Monostroma</u> <u>Spongomorpha</u>	<u>*Alaria</u> <u>Rhodymenia</u> <u>Ulva-Monostroma</u> <u>Spongomorpha</u>	<u>*Rhodymenia</u> <u>Bryozoa</u> <u>Alaria</u> <u>Ulva-Monostroma</u>
2.1 to 4.0	<u>*Porphyra</u> <u>Fucus</u> <u>Rhodymenia</u> <u>Enteromorpha</u>	<u>*Fucus</u> <u>*Porphyra</u> <u>*Ulva-Monostroma</u> <u>Rhodymenia</u>	<u>*Fucus</u> (patchy) <u>Gloiopeltis</u>	<u>Odonthalia</u> <u>Fucus</u> <u>Iridea</u> (1 observation)	<u>*Halosaccion</u> <u>*Rhodymenia</u> <u>Fucus</u> <u>Ulva-Monostroma</u>	<u>Fucus</u> (sparse)
4.1 to 6.0	no algae	<u>Porphyra</u> <u>Fucus (both sparse)</u> reservation)	no algae	<u>*Fucus</u>	no algae	no algae
6.1 +	no algae (1 observation)	no observation	no algae	no observation	<u>Porphyra</u> (sparse) (1 observation)	no algae

Table 15. --Continued.

Tidal elevation (ft)	Flat			
	Bedrock (Cape Sitkinak)		Cobble ,	
	Transect 1	Transect 2	(Low Cape) Transect 1	(Dolina Point) Transect 1
-2.0 to 0.0	<u>*Odonthalia</u> <u>*Rhodomela</u> <u>*Gigartina</u> <u>*Iridea</u>	<u>*Odonthalia</u> <u>Rhodymenia</u> <u>Gigartina</u>	<u>*Rhodomela</u> <u>*Rhodymenia</u> <u>Lithothamnion</u> <u>Bossiella</u>	no observation
0.1 to 2.0	<u>*Odonthalia</u> <u>Gigartina</u> <u>Iridea</u> <u>Fucus</u>	<u>*Gigartina</u> <u>*Iridea</u> <u>Rhodymenia</u>	<u>*Odonthalia</u> <u>Bossiella</u> <u>Rhodymenia</u>	<u>*Alaria</u> <u>Odonthalia</u> <u>*Rhodomela</u> <u>Ulva-Monostroma</u>
2.1 to 4.0	no algae	<u>Halosaccion</u> <u>Endocladia</u> (sparse)	<u>*Odonthalia</u> <u>Bossiella</u> <u>Lithothamnion</u> <u>Rhodymenia</u>	<u>*Odonthalia</u> <u>Rhodomela</u> <u>Fucus</u> <u>Ulva-Monostroma</u>
4.1 to 6.0	no algae	no algae	<u>*Odonthalia</u> <u>Fucus</u>	<u>*Odonthalia</u> (sparse)
6.1 to 8.0	no algae	no algae	<u>Odonthalia</u> (sparse)	no observation

Invertebrates

Populations of attached intertidal invertebrates were reduced at exposed outer coast locations. This situation agrees with other intertidal areas of the west coast of North America. Dayton (1973) states that along the open coast of Washington, algae are competitive dominants over invertebrates; Ricketts and Calvin (1968) noted that animals are most abundant along partially protected shores and least abundant along entirely unprotected or completely sheltered shores. Some examples follow.

Mytilus edulis.--This mussel is called a "quiet-water animal" by Ricketts and Calvin (1968). Although it is very abundant at many locations in the Kodiak Island area, it was not collected, or occurred in very low densities, at most exposed sites such as Chirikof Island, Sud Island, Sundstrom Island, Otter Island, and Narrow Cape. In more protected locations such as Three Saints Bay, Lagoon Point, Tonki Bay, and St. Paul Harbor, this species was quite common and formed dense bands in the middle intertidal zone. It is not entirely limited to these circumstances, however, as we found it growing on flat, exposed bedrock at Narrow Cape and it was almost absent at the partly protected site at Cape Kaguyak.

Balanus cariosus.--This barnacle occurred at almost all of our sites. It appeared, however, that there was a tendency for the species to be less common at exposed bedrock (especially flat bedrock) sites such as Chirikof Island, Cape Sitkinak, Pillar Cape, and Sea Otter Island, and more common at protected sites such as Three Saints Bay, Lagoon Point, Tonki Bay, and St. Paul Harbor. Individuals at the latter sites often were relatively quite large.

Katharina tunicata.--This chiton was also a ubiquitous species but it was not very common on exposed, flat, bedrock beaches or small boulder beaches such as the Geese Islands, Chirikof Island, Cape Sitkinak, Low Cape, and Dolina Point. The preferred habitat was immovable substrate with vertical relief.

Predatory snails and sea stars.--Several predatory invertebrates commonly were found in the intertidal zone. Although some species such as Nucella lima and Leptasterias neactis were ubiquitous, other common forms such as N. lamellosa, Evasterias troschelii, and Pisaster ochraceus were most abundant in protected habitats. Thus, we found large numbers of N. lamellosa and E. troschelii at Tonki Bay and St. Paul Harbor while no individuals were seen at Chirikof Island, Cape Sitkinak, and Sud Island.

Plants

Qualitative observations at several sites indicated predictable occurrences for two plant species, the red alga Rhodomelalarix and the surf grass Phyllospadix sp. These plants occurred most commonly and in highest densities on flat, bedrock beaches. Rhodomelalarix were seldom encountered except in this type of habitat. Phyllospadix were occasionally found growing in small patches in other habitats, but it formed extensive beds only on flat, bedrock beaches like Chirikof Island, Geese Islands, and Cape Sitkinak. While the occurrence of Phyllospadix on flat, bedrock sites was dramatic, most of our quantitative collections were not made in the extensive Phyllospadix beds. Thus, the relative dominance of this species is not apparent from transect line data.

Substrate stability

Most intertidal organisms require a stable substrate for survival. Unstable substrates (sand, gravel, cobble, boulder) usually support fewer and different organisms than do stable substrates (bedrock or large boulders). Small boulders at exposed sites such as Low Cape are tumbled by heavy wave action, so neither plants nor animals survive. We found very low densities of biota at exposed, small boulder sites like Low Cape and the southeastern side of Whale Island. Densities were much higher on similar-sized boulders in more protected locations like the southwestern side of Whale Island and North Shuyak Island.

It also appeared that scouring by sand or gravel was responsible for preventing colonization of adjacent bare rock surfaces.

Primary Productivity in the Kodiak Island Area

Marine phytoplankton productivity is generally assumed to exceed marine macrophyte productivity on a world-wide basis (Ryther 1969). It is apparent, however, that the productivity of coastal systems may be greatly enhanced by macrophyte production. In St. Margaret's Bay, Nova Scotia, an area with a high ratio of shoreline to water area, macrophyte production has been estimated to be three times that of phytoplankton (Mann 1972).

In the Kodiak Island area, a luxuriant growth of macrophytes occurs in a band from approximately the 20 m curve to mean high water of the intertidal zone. This band varies from about 400 m to 10,000 m in width. The intricate coastline of the Kodiak Island area, with its many bays, straits, islands, and reefs, results in a high ratio of shoreline (3,540 km) to water area.

The importance of kelp productivity in maintaining populations of crustaceans has been shown by Miller et al. (1971) for lobsters in eastern Canada. In this case the lobsters do not feed directly on the algae, but on herbivores such as urchins and on other animals higher up the food chain.

Kelps and other algae have been shown to have a direct relationship to king crab in Alaska. Bright et al. (1959) analyzed stomach contents of Cook Inlet king crab and commonly found several species of algae, including *Laminaria* and *Agarum*. The herbivorous green urchin, *Strongylocentrotus droebachiensis*, which feeds primarily on the kelps, was abundant in crab stomachs and was the most abundant food in the stomachs of small (30 to 50 mm) crabs.

Benthic (Non-Floating) Kelps

As part of our study, divers sampled subtidal kelps quantitatively at nine sites in the Kodiak Island area. Results of this study are being published separately (Calvin and Ellis 1978). Unless otherwise noted, the following information is from this study.

The biomass (mean wet weight) of benthic kelps at the sites, sampled over a depth range of 1.3 to 10 m, ranged from 4.8 to 18.3 kg/m². This range compares favorably with biomass in other parts of the world (Table 16). The most abundant species in the quadrats were *Laminaria dentigera*, *L. yezoensis*,

Table 16. --Summary of standing crop of **benthic** kelps from Kodiak Island and other areas. (All sampling was by hand collecting with scuba excepting **MacFarlane** who used grab sampling and cutting by hand).

Source	Location	Species	Season of sampling	Number of sites	No. of quadrats collected	Depths sampled (m)	Biomass (mean wet weight*)
Luning 1969	Helgoland, Germany	<u>Laminaria</u> <u>hyperborea</u>	Aug. to Nov.	--	61	0-5.5	0.1-11.1 kg/m ²
Mam 1972	Nova Scotia	<u>L. longicruris</u> and <u>L. digitata</u>	Summer	24	--	--	5.0-16 kg/m² (estimates)
MacFarlane 1952	Nova Scotia	<u>L. longicruris</u>	Summer	--	--	--	6.0-29 kg / m ²
Jupp and Drew 1974	Scotland	<u>L. hyperborea</u>	Dec., Jan., Mar., June	1	22	3 and 9	7.7 and 20.4 kg/m ²
John 1971	Spain	<u>L. ochroleuca</u> and <u>Saccorhiza</u> polychides	Sept.	7	--	1.6-18.6	0.26-17.9 kg/m²†
Calvin and Ellis 1978	Kodiak Is., Alaska	<u>L. dentigera</u> and other non-floating kelps	May	9	55	1.3-10	4.8-18.3 kg/m ²

* The means are for different depths for some studies and different geographic areas for others.

† Estimated from organic weight figures.

Pleurophycus gardneri, and Agarum cribrosum. L. dentigera was usually dominant, with its greatest development at depths between 3 and 10 m where it reached a maximum size larger than has been reported elsewhere (maximum length 428 cm, maximum width 85 cm).

Canopy (Floating) Kelps

In 1913 a survey was made of floating kelps (Nereocystis luetkeana and Alaria fistulosa) in the Kodiak region (Rigg 1915). The total standing stock weight was estimated to be 2,588,106 tons (2.3×10^9 kg). Aerial surveys (Sears and Zimmerman 1977) confirmed that in 1976 the location of the beds was much the same as it was in 1915. We collected two representative specimens of N. luetkeana to determine their size as an aid in evaluating the role of kelps in the Kodiak Island area. The net weight of one specimen was 39.5 kg and of the other, 40.4 kg. Judging from the immense size of these N. luetkeana, the large size of Laminaria dentigera (see above), and the wide distribution and density of these plants around Kodiak Island, it seems ideal kelp habitat.

Productivity of Phytoplankton

Using coastal charts we determined that the Kodiak Island area's outer continental shelf occupies $3.57 \times 10^{10} \text{ m}^2$. This includes all of the marine areas within the 100-fathom line from southwest of the Trinity Islands ($56^\circ 35' \text{N}$, $155^\circ 05' \text{W}$) to the western side of Portlock Banks ($58^\circ 35' \text{N}$, $152^\circ 00' \text{W}$).

Although no direct measurements are available, primary production by phytoplankton in the Kodiak Island area is thought to exceed $200 \text{ g/C/m}^2/\text{yr}$ (U.S. Department of the Interior 1977). Assuming a uniform phytoplankton productivity of $0.2 \text{ kg/m}^2/\text{yr}$ throughout the shelf area, the total value would be $7.14 \times 10^9 \text{ g/C/m}^2/\text{yr}$.

Estimates of Biomass

One of the purposes in taking quantitative samples was to estimate the biomass of particular organisms present on certain stretches of coastline. The biomass estimate represents the amount of a resource at stake in a certain area and can be one of the many parameters weighed in assessing potential environmental impact in different areas. For example, relative biomass values for several species in an area are used by Isakson et al. (1975) in comparing postulated oil impacts. Also, biomass information may someday be useful in evaluating the roles of intertidal organisms in the total ecosystem. In this section a simple approach for making the biomass estimates is used.

As described in a previous section, sampling was done along transect lines laid perpendicular to the shoreline and quadrat samples were taken at regular intervals along the lines. (Transect lines laid parallel to the shoreline and/or laid all in one zone or at one elevation are ignored in this analysis.) The lines extended from above the highest level at which significant amounts of intertidal organisms were found to as low a level as possible depending on the state of the tide. This was at least the 0-ft tide level in most cases. Data were analyzed from 12 sites with one to three transect lines sampled per site.

For each species an estimate was obtained for each transect line j of the biomass B_{ij} lying along a 1-m-wide section of beach under the transect line at site i :

$$B_{ij} = \sum_{k=1}^l B_{ijk} P_{ij}$$

where B_{ijk} = biomass (wet weight in grams) in sample k of line j of site i ,
 $P_{ij} = \text{sampling interval (meters)} \div \text{quadrat size (square meters) used at transect line } j \text{ of site } i$, and
 l = number of samples in line j at site i .

Whenever a site was sampled by more than one transect line or one visit to the same transect line, the lines or visits were assumed to be random in time and space within the site. All lines for that site were averaged to an unweighed estimate,

$$B_{i.} = \sum_{j=1}^n B_{ij} / n$$

for that site i , where n = number of transects.

If it can be assumed that the sites are chosen randomly from among all rocky beaches and the transect lines are random within sites, then an estimate of the average biomass of a particular species per unit length (meter) of rocky shoreline can be obtained,

$$B_{..} = \sum_{i=1}^{n'} B_{i.} / n'$$

where n' = number of sites.

An estimate of the amount of rocky shoreline was obtained from the aerial surveys (Zimmerman et al. 1977a). An estimate of total biomass of particular species on rocky beaches (species may not be exclusive to rocky beaches) in the Kodiak Island area equals the total length (meters) of rocky beaches multiplied by biomass per unit length, $B_{..}$. The confidence interval for such an estimate, assuming length of rocky beach is a known constant, is proportional to the confidence interval of the $B_{..}$, which can be calculated assuming $B_{..}$ is normally distributed and its variance is estimated by $S^2_{B_{i.}} / n'$.

Estimates for total biomass of different intervals within the Kodiak Island area were made by knowing the lengths of rocky shoreline within the area and making the appropriate multiplication. This assumes either that the rocky beach types are proportioned equally among the intervals or there is no difference in $B_{i.}$'s between the beach types and also that there are no geographically correlated differences in $B_{i.}$'s within beach types.

$B_{..}$ as estimated from the 12 $B_{i.}$'s and the sample standard deviation $B_{i.}$ were calculated for Fucus, where $B_{..} = 38,265.85$ g/m and $S_b = 37,853.71$.

Combining this with information from Table 1 results in an estimate of $(38,265.85 \text{ g/m} \times 1,609 \text{ m/mile} \times [1,160 + 304.5] \text{ miles of rocky beach}) = 9.02 \times 10^7$ kg of Fucus on rocky beaches of the Kodiak island region. A 95%

confidence interval is calculated to be:

$$\{38.26585 \pm t_{.05} \frac{(37.854)}{\sqrt{12}} (1,609 \times [1,160 + 304.5])\} = 3.35 \times 10^7 \text{ kg}$$

< total biomass < $1.47 \times 10^8 \text{ kg}$.

One of the precautions that should be taken when making comparisons within the whole area is to check the assumption that there is no significant difference between the B.'s on different types of rocky beaches. This is important if we know the beach types are not proportioned equally among all areas. In the case of Fucus, no significant differences between bedrock vs. boulder beaches, flat vs. nonflat beaches, or exposed vs. protected beaches were detected. However, because of large within-beach-type variability and small number of samples, the power of our tests was quite low and large differences could go undetected.

There are several other factors which could tend to limit the applicability of our data to this type of analysis:

- 1) Sites were not chosen entirely randomly. Biomass estimates are biased in favor of gently sloping beaches (with spatially wide zonation) since vertical beaches (with spatially narrow zonation) are more difficult or impossible to sample. We also attempted to sample examples of as many types of beaches as possible. Some of these may have been geographically rare and therefore could have received disproportionate emphasis.
- 2) Sampling at each site was not entirely random. Transect lines were chosen for representativeness of biological cover. Though no conscious attempt was made to choose areas of high biotic abundance, those were often the areas of greatest biological interest or were representative of most of the beach.
- 3) Time of visits may influence some of the biomass estimates. For instance, motile invertebrate species such as Nucella or ephemeral algae such as Porphyra may occur during certain seasons but not others.
- 4) Estimates for some species, especially Alaria, are known to be incorrect due to incomplete sampling of their entire vertical range and wide seasonal variation of biomass.

Estimates of Species Diversity

Measures of diversity were calculated for most transect line samples from rocky beaches, but the usefulness of these calculations is very limited. A serious problem which was not resolved, particularly for animals, was that the number of species found depends on how exhaustively the collections were made. Many of the smaller animals hide under rocks and in crevices where they could not be recovered. Therefore, it should be emphasized that the species diversity calculations apply to the samples as collected and not necessarily to the intertidal population as a whole. We undoubtedly missed some species which were present. Brillouin's formula for measuring information content per symbol in a finite message as recommended by Pielou (1969) for completely censused collections was used. The formula is:

$$H = \frac{1}{N} \sum_{i=1}^S \ln \frac{N!}{N_1! N_2! \dots N_s!},$$

where N is the total number of individuals, s is the number of exclusive taxa (species), and N_i is the number of individuals in the i th taxa, so that $\sum N_i = N$.

The wet-weight units of plant-type* species were treated as individuals to be compatible in the factorial functions of the formula (Pielou 1969). Diversities of plant-type (weights) and animal-type† (numbers) species were calculated separately.

Animal Species Diversity

Animal species diversity was divided into three components:

1) $H(C)$ is the "class diversity" of the taxa listed in Table 17. Some of the taxa are classes and others are orders or phyla, but each is exclusive of all the others. Collections can be consistently and confidently identified to these taxa, so this component will be consistent and comparable between collections.

When an attempt was made to identify organisms to a taxonomic level beyond those used in $H(C)$, i.e., family, genus, or species, two categories exist.

2) $H_C(S)_A$ is the weighted average of the "within-class" diversity of the "classes" in group A of Table 17. "Classes" in group A are moderately consistent in their identification to the species level and tend to be diverse in our samples.

3) $H_C(S)_B$ is the weighted average of the measurable "within-class" diversity of the "classes" in group B of Table 17. Identification to the more specific levels is not consistent in group B "classes". The measurable diversity of these "classes" also tends to be low in our collections, either because of lack of specific identification capabilities as in *Oligochaeta* or actual low diversity as in *Asteroidea*.

Thus, $H_C(S)_A$ is moderately consistent between collections and may be compared as a measure of diversity, while $H_C(S)_B$ cannot be used as a consistent measure of diversity but will hopefully be near-zero much of the time.

It can be shown that summing the three components will equal the simple "species" diversity index H calculated from the most specific level of identification (Pielou 1969). $H(C)$ is by far the largest component of H , so a large portion of the diversity is measured in the most comparable component.

Plant Species Diversity

Plant species diversity is divided into $H(C)$ and $H_C(S)$. The plant "classes" are listed in Table 18. $H_C(S)$ is the weighted average of the "within-class"

* Plant-types are those species where morphometry makes it impossible to count individuals, e.g., sponges and some algal species.

† Animal-types are those species which can be individually counted, e.g., mussels and barnacles.

Table 17---Animal taxa that were identified consistently and confidently in **intertidal collections.**

<u>Group A Taxa:</u>	<u>Group B Taxa:</u>
Identification to species level <u>moderately consistent</u>	Organisms not always identified to species level or groups are <u>of low diversity</u>
Polychaeta	Hydroidea
Polyplacophora	Turbellaria
Pelecypoda	Rhyncocoela
Gastropoda	Oligochaeta
Thoracica	Pycnogonida
Cumacea	Asteroidea
Iso-poda	Echinoidea
Amphipoda	Holothuroidea
Decapoda	Sipunculida
	Echiuroidea
	Brachiopoda
	Teleostei
	Harpactacoida
	Acarina

Table 18. --Taxa **used** to calculate measures of diversity for plants.

<u>Taxa</u>
Ulotrichales
Cladophorales
Codiales
Ectocarpales
Spacelariales
Chordariales
Desmarestiales
Dictyosiphonales
Bangiales
Nemalionales
Cryptonemiales
Gigartinales
Rhodymeniales
Ceramiales
Bacillariophyceae
Phycomycetes
Li chens
Anthophyta
Porifera
B ryozoa
Urochordata

species diversity of all taxa. Our analysis shows that $H(C)$ measures the major portion of the diversity in plant species also.

In making calculations it was assumed that organisms not identified to species are distinct from other organisms of the same taxa that have been identified to species and that the unspecified organism represents only one species unless otherwise noted.

Results

After measures of diversity were calculated for most transect line samples from rocky beaches, class diversity $[H(C)]$ for animal-type organisms and species diversity $[H(C) + H(S)]$ for plant-type organisms were plotted versus sample elevation (Figures 106-109). Very little of interpretable significance was readily apparent. It does appear, however, that samples from Three Saints Bay had significantly higher animal diversity measures, and that Lagoon Point and Cape Sitkinak had a greater than average proportion of samples with zero plant diversity. Comparisons between stations are confounded by elevation effects, although relationships between elevation and diversity measure are not obvious in the data.

Within-site analyses also indicated that little was gained by calculating diversity data. For instance, at Sud Island (Table 19), as would be expected, plant diversity and number of species were low above the zone of Fucus dominance (greater than 2.1 m). Below the 2.1 -m level the number of species and the diversity values were relatively the same although two of the lines showed slightly higher values in the zones dominated by red algae.

Correlation Analysis

Transect line data from the 1976 Surveyor cruise (Lagoon Point, Cape Kaguyak, Dolina Point, Low Cape, Cape Sitkinak) were pooled and correlation coefficients (r) were calculated for 1,196 pairs of organism variables. Correlations included plant weight with plant weight (Table 20), plant weight with animal number (Table 21), plant weight with animal weight (Table 22), animal number with animal number (Table 23), and animal weight with animal weight (Table 23).

Although r exceeded the table values for significance for several pairs*, none was greater than 0.6. Several suspected associations were indicated but many unexplained correlations were also found. Because of the low values, it was felt that these results should not be used, by themselves, to indicate organism associations.

INTERTIDAL SURVEY--SANDY AND GRAVELLY BEACHES

The Kodiak Island area has approximately 776 miles of gravelly beaches and 192 miles of sandy beaches (Table 1). These gravelly and sandy beaches occur predominantly near river mouths or on the southeast and northwest sides of Kodiak Island and on Chirikof Island and the Trinity Islands. They

* Normality assumptions of the r statistic are severely violated so statistical significance is misleading.

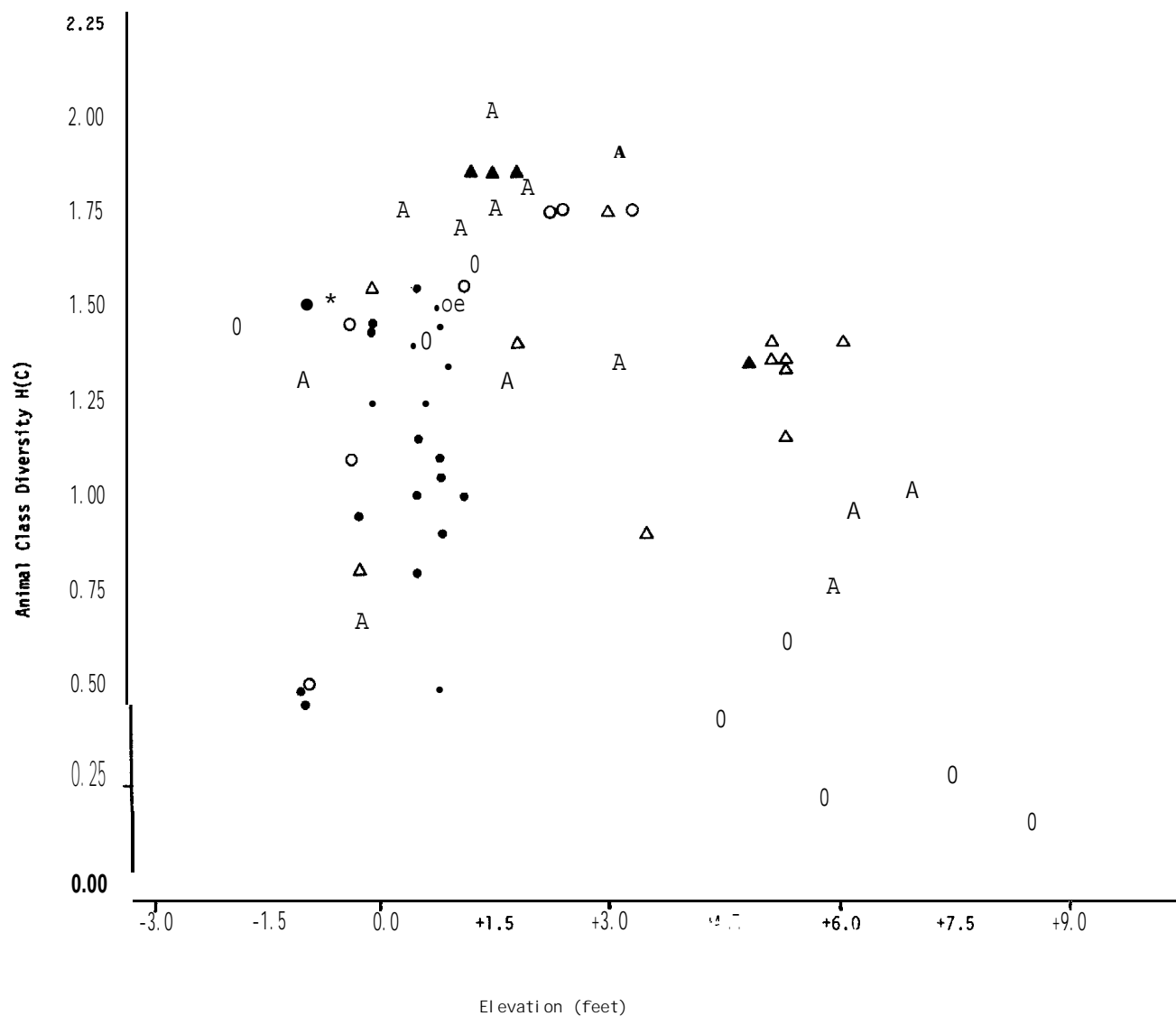


Figure 106. Class diversity, $H(C)$, per quadrat of animals sampled at Sud Island \circ , Chirikof Island \bullet , Sundstrom Island \triangle , and Three Saints Bay \blacktriangle during May 1975.

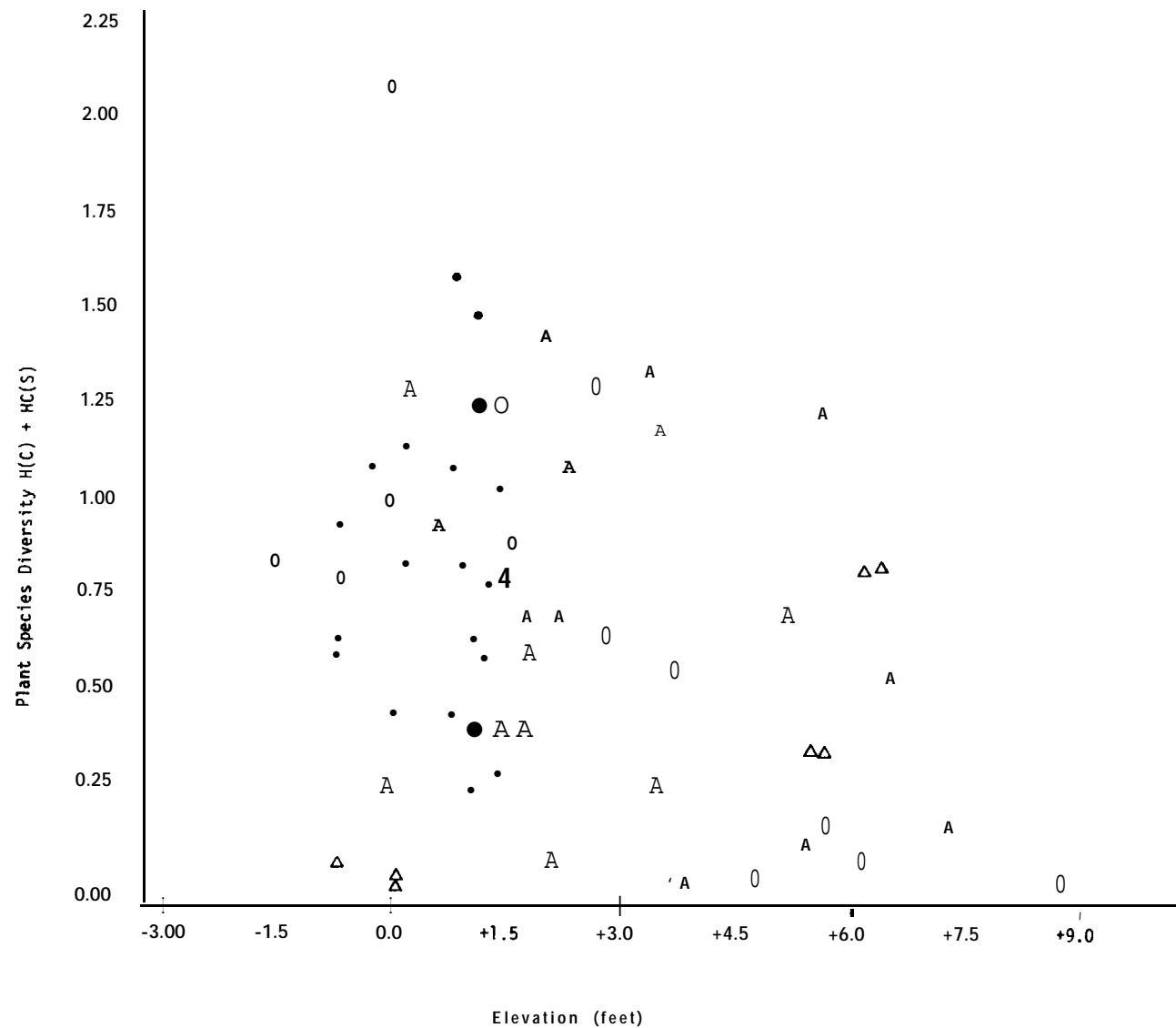


Figure 107. Species diversity, $H(C)+HC(S)$, per quadrat of plant-type organisms sampled at Sud Isl and O, Chirikof Isl and ●, Sundstrom Island A, and Three Saints Bay ▲ during Play 1975.

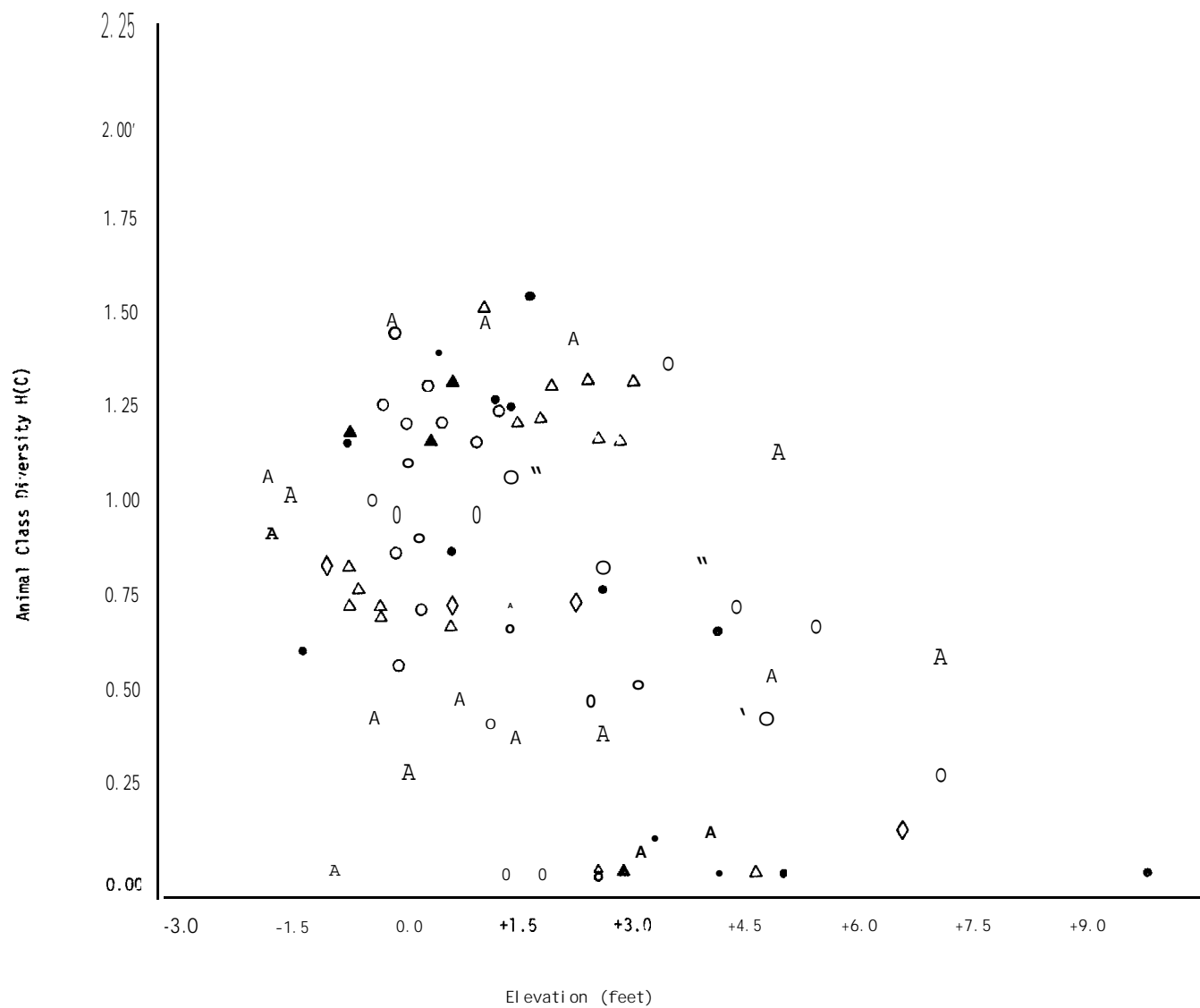


Figure 108. Class diversity, $H(C)$, per quadrat of animals sampled at Cape Sitkinak \circ , Cape Kaguyak \bullet , Lagoon point (transects 1 and 2) \triangle , Lagoon Point (transect. 3) \blacktriangle , and Low Cape \diamond during May 1976.

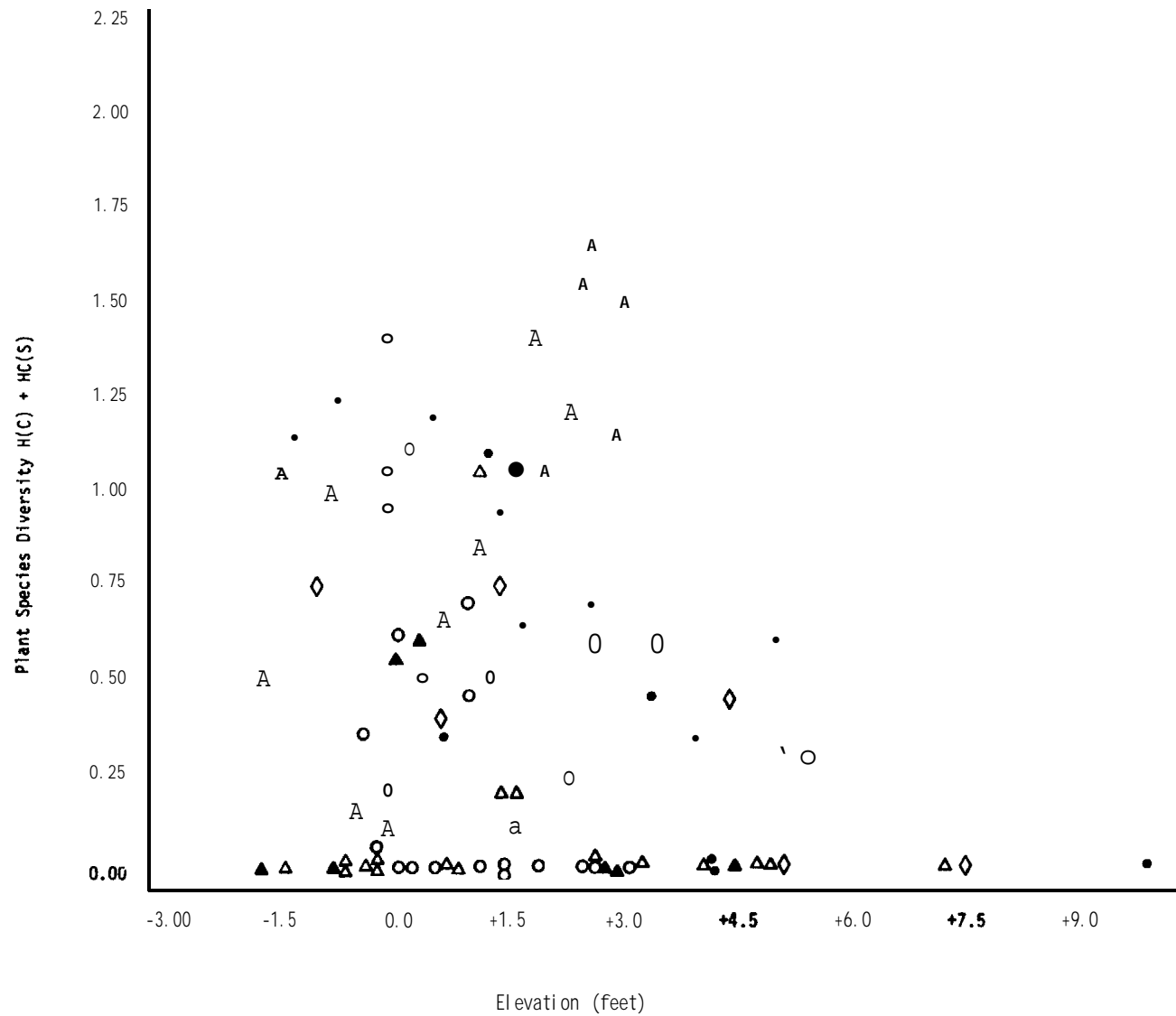


Figure 109. Species diversity, $H(C) + HC(S)$, per quadrat of plant-type organisms sampled at Cape **Sitkinak** ○, Cape **Kaguyak** ●, Lagoon Point (transects 1 and 2) A, Lagoon Point (transect 3) A, and Low Cape ◇ during May 1976.

Table 19. --Plant [H(C)] and **animal** [H(C)] diversity values for samples at different tidal elevations at Sud Island, May **and August** 1976. Pooled values **for** all samples collected during both **trips** are also **given**. Dominant algae at **1.01-2.10 m = Fucales**; at 0.00-1.00 m = Rhodophyceae; at 0.00 m = **Laminariales**.

Date and transect	Height (m)	Plant diversity	No. of plant species	Animal diversity	No. of animal species	No. of samples
May 1976	2.10	0.04	---	0.26	---	(1)
	1.01-2.10	0.19	8	0.82	11.4	(5)
	0.00-1.00	1.03	11.4	1.59	27.0	(6)
	0.00	0.54	9	1.0	3.3	(2)
August 1976	2.10	0.40	4.5	0.24	6	(2)
Transect 1	1.01-2.10	0.31	4.0	0.86	8.3	(4)
	0.00-1.00	1.11	7.0	1.20	32	(5)
	0.00	0.59	8.8	1.32	50	(4)
August 1976	2.10	0.13	2.5	0.54	8.9	(11)
Transect 2	1.01-2.10	0.94	8.0	1.29	22.7	(10)
	0.00-1.00	0.60	8.6	1.49	29.6	(5)
	0.00	0.04	7.0	1.58	78	(1)
Pooled Values	2.10	0.16	2.7	0.44	8.5	(14)
	1.01-2.10	0.61	7.2	1.08	16.7	(19)
	0.00-1.00	0.92	9.0	1.44	29.5	(16)
	0.00	0.50	8.6	1.27	49.1	(7)

[illegible]

Table 21.--Correlation matrix between plant weight and animal number for several of the more abundant species collected in quantitative 1/16 m² transect line samples. Only significant values are shown.

	Endocladia	Fucus	Porphyra	Halosaccion	Odonthalia	Ulvoids	Spongomorpha	Rhodomela	Rhodymenia	Algal association	Polysiphonous red algae	Alaria	Laminaria	Phyllospadix	Coral lines
<u>Littorina sitkana</u>		.119			.220							-.140			
<u>Balanus glandula</u>															
<u>Mvtilus edulis</u>	.231														
<u>Collisella pelta</u>															
<u>Notoacmea personata</u>	.472									.180					
<u>Nucella lima</u>					.143			.113							.181
<u>Balanus cariosus</u>												.183			
<u>Leptasterias hexactis</u>							.114					.203			
<u>Notoacmea scutum</u>										.189					
<u>Katharina tunicata</u>					.144	.257						.187			.489
<u>Tonicella lineata</u>															
g [?															
Polychaetes												.210			.296
Amphipods					.145			.189				.128		.279	.207
Margarites sp.					.138				.202						
Sea cucumbers															
Hiatella arctica															.222

Table 22. --Correlation matrix between plant weight and animal weight for several of the more abundant species collected in quantitative 1/16 m² transect line samples. Only significant values are shown.

	<u>Endocladia muricata</u>	<u>Fucus distichus</u>	<u>Porphyra</u> sp.	<u>Halosaccion glandiforme</u>	<u>Odonthalia</u> <u>F. occosa</u>	<u>Ulvoids</u>	<u>Spongomorpha</u> sp.	<u>Rhodomela larix</u>	<u>palmata</u>	<u>Alga association</u>	<u>Polysiphonous red algae</u>	<u>Alaria</u> sp.	<u>Laminaria</u> sp.	<u>Phyllospadix</u> sp.	<u>Corallinæ</u>
<u>Littorina sitkana</u>	.395	.235										-.115			
<u>Balanus glandula</u>							.141								
<u>Mytilus edulis</u>															
<u>Collisella pelts</u>															
<u>Notoacmea persona</u>	.386	.118				.218				.404	.186	.288			
<u>Nucella lima</u>								.129							.129
<u>Balanus cariosus</u>							.332								
<u>Leptasterias hexactis</u>							.171								
<u>Notoacmea scutum</u>						.181					.186	.288			
<u>Katharina tunicata</u>															.339
<u>Tonicella lineata</u>					.168										
<u>Halichondria panicea</u>												.210			.296
<u>Polychaetes</u>								.207				.205			.338
<u>Amphipods</u>															
<u>Margaritas</u> sp.					.169		.189								.253
<u>Sea cucumbers</u>							.117					.252			
<u>Hiatella arctica</u>							.130					.199			

Table 23.--Correlation matrix between animal number and animal weight and between animal weight and animal weight for several of the more abundant species collected in quantitative 1/16 m² transect line samples. Only significant values are shown.

	<u>Littorina sitkana</u>	<u>Balanus glandula</u>	<u>Mytilus edulis</u>	<u>Collisella pelta</u>	<u>Notacmea persona</u>	<u>Nucella lima</u>	<u>Balanus cariosus</u>	<u>Leptasterias hexactis</u>	<u>Notacmea scutum</u>	<u>Katharina tunicata</u>	<u>Tonicella lineata</u>	<u>Halichondria panicea</u>	<u>Polychaetes</u>	<u>Amphipods</u>	<u>Margarites</u>	<u>Sea cucumbers</u>	<u>Hiatella arctica</u>
<u>Littorina sitkana</u>																	
<u>Balanus glandula</u>	.172																
<u>Mytilus edulis</u>	371	.301															
<u>Collisella pelta</u>			.598														
<u>Notacmea persona</u>																	
<u>Nucella lima</u>						.166											
<u>Balanus cariosus</u>																	
<u>Leptasterias hexactis</u>			.221	.137	.427												.137 .158
<u>Notacmea scutum</u>					.15												
<u>Katharina tunicata</u>			.129				.174				.246				.251		
<u>Tonicella lineata</u>																	
<u>Halichondria panicea</u>																	
<u>Polychaetes</u>			.145	.111			.147			.166			.334		.271		.301 .347
<u>Amphipods</u>							.175			.463					.240		
<u>Margarites sp.</u>															.19		
<u>Sea cucumbers</u>			.357	.250											.199		
<u>Hiatella arctica</u>																	

range in length from small pockets isolated between rocky shores to 40-km stretches of beach and lagoon systems.

To verify the accuracy of the aerial survey, we investigated several representative gravelly and sandy beaches on foot. Generally, we found the gravelly beaches were composed of an aggregate of coarse sand and pebble-sized (up to 60 mm) gravel (Figure 110). Sandy beaches were usually composed of well-graded, sand-sized particles (Figure 111).

Because of their unconsolidated nature, both of these beach types are subject to particle movement and morphological changes from surf resulting in an almost complete absence of sessile benthic organisms. Sandy and gravelly beaches do contain infaunal organisms, however. Characteristic sandy beach organisms, for instance, consist of highly motile epifauna (e.g., amphipods such as Euhaustorius and the sand lance Ammodytes hexapterus), rapidly-burrowing infauna (e.g., the razor clams Siliqua patula and S. alta and polychaetes such as Nephtys sp.), and slow-burrowing but strong-shelled species (e.g., the surf clam Spisula polynyma).

Gravelly Beaches

We sampled gravelly beaches at Whirlpool Point and Lagoon Point with a 1-liter corer and examined a gravelly beach at Pasagshak Bay.

Both general observations and analysis of the core samples indicated that biota were scarce at these sites. Neither surface dwellers nor infauna were evident. Analysis of the core samples indicated that amphipods were the most common organisms at Whirlpool Point (Table 24), and nematodes at Lagoon Point (Table 25). Amphipod numbers were quite high in some of the Whirlpool Point samples (maximum 43,100 /m²).

Sandy Beaches

Fourteen sandy beaches were sampled in conjunction with the AD F&G Razor Clam Study (Table 26); for descriptions of sites, see Kaiser and Koenigsberg (1976). Razor clams (Siliqua patula and S. alta) were the most common molluscs encountered in the study (Table 27). Polychaete worms, especially Scolecipis squamatus and Haploscoloplos elongatus, were also quite common (Table 28). More complete data showing the number and distribution of organisms with respect to tidal height are contained in appendix 3 of Kaiser and Koenigsberg (1976).

INTERTIDAL SURVEY--MUDDY BEACHES

Muddy beaches are relatively rare in the Kodiak Island area, comprising only 0.2% of the coastline (Table 1). While verifying the accuracy of the aerial survey, however, it was apparent that the gravelly areas at the upper ends of bays often contain large amounts of silt and mud. Many of the infauna in these areas are also found in muddy strata. On a mixed aggregate beach in Izhut Bay, for example, we found clam populations composed of Mya arenaria, Protothaca staminea, and Clinocardium nuttalli, and several species of polychaete worms.

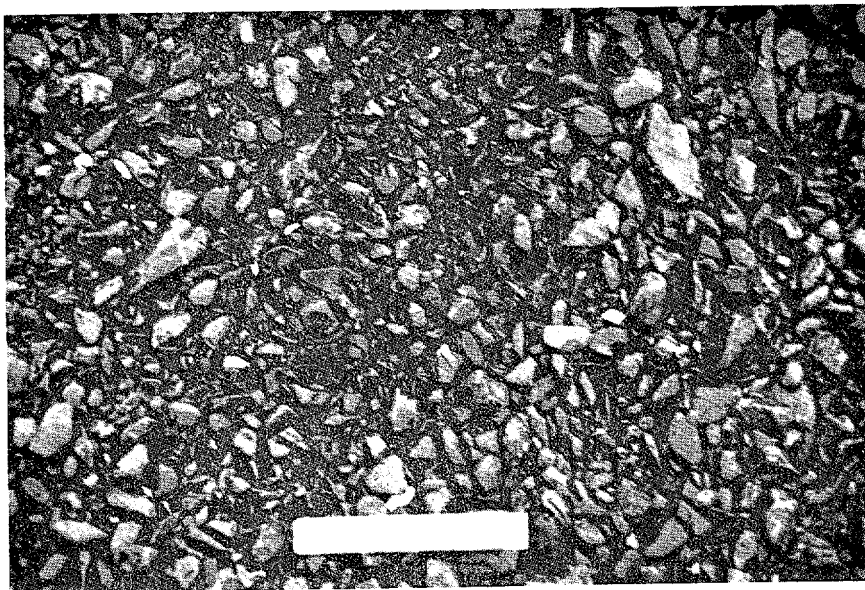


Figure 110. Surface view of gravel beach.

Figure 111



Figure 111. Surface view of sandy beach. Note razor clam hole.



Table 24.--Organisms in 1-liter gravel cores at Whirlpool Point, 14 May 1976.

Elevation (m)	Core depth(cm)		Organism	No. of organisms
	0-10	10-20		
4.63	x		---	
3.87	x		Oligochaeta	1
3.23	x		Oligochaeta	1
			Polychaeta	1
2.80	x		Amphi poda-Gammari dae	9
2.80	x		|| "	19
2.44	x		" u	65
2.44		x	" ||	9
2.44	x		" "	13
2.01	x		" "	11
2.01		x	" "	7
2.01	x		" "	68
			Nemertea	1
1.65			Amphipoda-Gammaridae	431
			<u>Turtonia occidentalis</u>	1
1.65		x	Amphi poda-Gammari dae	430
1.65	x		|| ||	300
1.19	x		" "	61
1.19		x	" ||	200
1.19	x		" "	6.1
0.49	x		Nemertea (Amphiporidae)	1
0.40	x		---	
0.40		x	Amphi poda-Gammari dae	103
0.40	x		" "	14

Table 25. --Organisms in 1-liter gravel cores at Lagoon Point, 16 May 1976. *

Transect meter number	Core depth(cm)		Organism	No. of Organisms
	0-10	10-20		
0	x		---	--
5	x		Nematoda	39
			<u>Mytilus edulis</u>	1
10	x		Nematoda	4
15A	x		Oligochaeta	3
			<u>Fabricia sabella</u>	2
15B	x		Nematoda	3
20A	x		Nematoda	15
20A		x	Nematoda	22
20B	x		Nematoda	26
25A	x		Polychaeta	1
25A		x	Archiannelida	1
			Amphipoda-Gammaridae	1
25B	x		Archiannelida	6
			Polychaeta	1
30A	x		Amphipoda-Gammaridae	7
			Polychaeta	1
30A		x	Polychaeta	2
			Nematoda	1
30B	x		Polychaeta	2

* Elevations were not measured for this site. The transect line ran from the water's edge (approximately MLLW) to approximately 3 m above MLLW.

Table 26. --Location of stations and some physical characteristics of 14 Alaska Peninsula and Kodiak Island sandy beaches studied 13 May - 30 August 1976. (Kaiser and Koenigsberg 1976)

Beach	Station	Approximate Lat. & Long.	Exposure direction of beach (magnetic degrees)	Estimated length of beach Siliqua habitat (km)	Width of beach at station (m)*	Slope distance from +1 to -1 ft tide level (m)
Ocean Bay	B1	57°06'40" N 153°10'00" W	148°	7.08	91.20 (-1)	23.79
Tanner Head	B2	56°52'50" N 154°13'20" W	114°	3.70	155.55 (-3)	22.88
Halibut Bay	B3	57°21'35" N 154°45'40" W	32°	7.61	114.38 (-1.7)	28.98
Swikshak†	B4	58°36'35" N 153°43'10" W	181°	7.24 (-2)	201.91 (-2)	62.83
Village§	B5	58°34'10" N 153°50'30" W	102°	6.92 (-4)	383.39 (-4)	234.24
Big River	B6	58°35'40" N 153°52'10" W	76°	3.22	900 (-4)	131.83
Hallo Bay¶	B7	58°20'10" N 154°04'15" W	64°	6.84	676.66 (-3)	172.52
Kukak**	B8	58°21'20" N 154°06'10" W	90°	1.28	598.93 (-2)	51.82
Bumble Bay	B9	57°16'50" N 154°40'30" W	201°	1.61	108.97 (-1)	26.67

Table 26. --Continued.

Beach	Station	Approximate Lat. & Long.	Exposure direction of beach (magnetic degrees)	Estimated length of beach <u>Siliqua</u> habitat (km)	Width of beach at station (m)*	Slope distance from +1 to -1 ft tide level (m)
Tugidak	B10	56°30'40" N 154°28'40" W	153°	?††	73.15 (-1)	23.62
Dakavak§§	B11	58°03'40" N 154°41'10" W	150°	2.4	179.07 (-2)	20.57
Katmai¶¶	B12	58°01'10" N 154°54'58" W	146°	4.02		
Kashvik	B13	57°56'40" N 155°05'35" W	108°	2.01	1,798.92 (-1)	917.75
Alinchak***	B14	57°49'50" N 155°20'10" W	106°	1.61	735.79 (-1)	156.06

* Beach width measured from high tide to low tide indicated in feet within parenthesis.

† Measurements refer to that area of Swikshak beach from the mouth of the Swikshak River northeast to the first prominent rocky bluff.

§ Steep embankment and rock cobble begins just above the zero (0.00 ft) mean low water level.

¶ The beach studied and measured is that beach area between Hallo Creek and Hook Creek.

** Only one beach within an un-named bay within the Kukak Bay system was investigated.

†† Extent of razor clam habitat is unknown.

§§ Measurements refer to the beach west of the major river in Dakavak Bay.

¶¶ No transect was established at Katmai Bay. Measurements refer to beach east of the Katmai River.

***Measurements refer to the northernmost beach within Alinchak Bay.

Table 27. --Numbers of bivalve molluscs in plots on 12 Alaska Peninsula and Kodiak Island sandy beaches, 13 May - 30 August 1976. (Kaiser and Koenigsberg 1976)

Beach	No. of tide level stations examined*	<u>Siliqua patula</u>	<u>Siliqua alta</u>	<u>Siliqua polynyma</u>	<u>Clinocardium nuttalli</u>	<u>Macoma lama</u>	<u>Macoma balthica</u>	<u>Macoma calcareo</u>	<u>Macoma loveni</u>	<u>Macoma nasuta</u>	<u>Macoma yoldiformis</u>	<u>Littorina sitkana</u>	<u>Mya arenaria</u>	<u>Protothaca staminea</u>	<u>Tellina lutea alternidentata</u>	<u>Tellina nucleoides</u>	<u>Tressus capax</u>
Tanner Head	7	25	0	1	0	4	0	0	0	0	1	0	1	0	0	0	0
Halibut Bay	10	268	3	7	3	1	0	0	0	0	0	0	0	0	1	0	1
Swikshak	6	121	3	17	0	1	1	0	0	0	1	0	0	0	0	1	0
Village	5	208	26	9	0	0	0	0	0	0	0	0	0	0	0	0	0
Big River	5	211	2	11	2	1	1	0	0	0	0	0	0	0	3	0	0
Hallo Bay	8	63	3	21	5	64	16	1	2	0	0	0	20	0	2	0	0
Kukak Bay	10	123	28	37	16	150	3	0	0	0	3	0	0	1	2	0	0
Bumble Bay	6	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tugidak	5	5	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dakavak	7	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kashvik	7	120	0	4	0	19	11	0	0	0	0	0	0	0	0	0	0
Alinchak	4	8	5	2	0	0	1	0	0	0	0	0	0	0	0	0	0

* Plots at each station were 21 x 3 m.

Table 28---Numbers of invertebrates (polychaetes and nemerteans) in volumetric samples of sand from 12 Alaska Peninsula and Kodiak Island beaches 13 May - 30 August 1976. (Kear and Konigsberg 1976)

Beach	Volume of sand sieved, in thousands of liters	<u>Scoelepis squamatus</u>	<u>Haploscoloplos elongatus</u>	<u>Ophelia assimilis</u>	<u>Anaites groenlandica</u>	<u>Eteone longa</u>	<u>Glycinde picta</u>	<u>Cistenides brevicoma</u>	<u>Nephtys caeca</u>	<u>Nephtys californiensis</u>	<u>Nephtys ciliata</u>	Nemertea	<u>Cerebratulus californiensis</u>
Tanner Head	2.1	137	0	14	0	0	0	0	20	0	0	0	0
Halibut Bay	2.1	231	29	13	0	2	4	0	11	0	0	5	0
Swikshak	1.8	359	18	0	0	7	0	0	20	13	3	0	1
Village	1.2	248	30	1	0	0	0	2	28	19	0	0	3
Big River	1.5	157	44	9	0	0	0	0	7	2	0	0	1
Hallo Bay	1.8	264	14	0	6	0	0	2	57	0	0	1	4
Kukak	3.0	912	16	0	4	1	1	0	80	1	0	5	3
Bumble Bay	0.2	3	0	4	0	0	0	0	0	0	0	0	0
Tugidak	1.4	0	9	4	0	2	7	0	0	7	0	0	0
Dakavak	1.5	24	1	111	2	1	0	0	0	104	0	3	1
Kashvik	1.7	270	24	9	0	5	2	0	23	21	0	0	0
Alinchak	1.1	496	0	0	0	0	0	0	13	9	0	0	0

The only area we sampled which had a substrate of soft mud was at South Sitkalidak Lagoon (Figure 112). The entrance to the lagoon is a narrow neck which opens into a large (about 2 km²) bay with a mud bottom. At high tide the lagoon is filled with water and even at low tide some areas are covered by tidal run-off or brackish streams (Figures 113 and 114).

We sampled an area of soft mud near the entrance of the lagoon using a transect line and a 1-liter corer. Samples were characterized by large numbers of a few species. The most numerous organism was an oligochaete worm. Other organisms included three species of polychaete worms, three species of clams, nemertean worms, and amphipods (Table 29).

We made qualitative observations by walking over the area and digging in the mud with a shovel. The distribution of organisms appeared to be patchy, with species aggregated according to microhabitat. For this reason our transect line sampling was an inadequate representation of the extensive and varied area. During our qualitative sampling we found aggregations of several species of polychaete worms and clams (for instance Mya arenaria), many of which could not have been adequately sampled using our standard corer because of their large size or because they occurred deeper in the substrate than we normally sampled. Juvenile starry flounder, small adult shrimp, and larval shrimp were found in the tidal streams. Sandy areas along the edges of tidal streams were often populated with sand lances. Algal species in the mud-sand-b vel area were Fucus distichus, Scytosiphon lomentaria, Desmarestia sp., Polysiphonia sp., and Monostroma sp. The seagrass Zostera marina also occurred in small patches in the mud habitat.

On a rock berm at the head of the lagoon we observed littorine snails, Mytilus edulis, Balanus sp., and the algae Odonthalia floccosa and Monostroma sp,

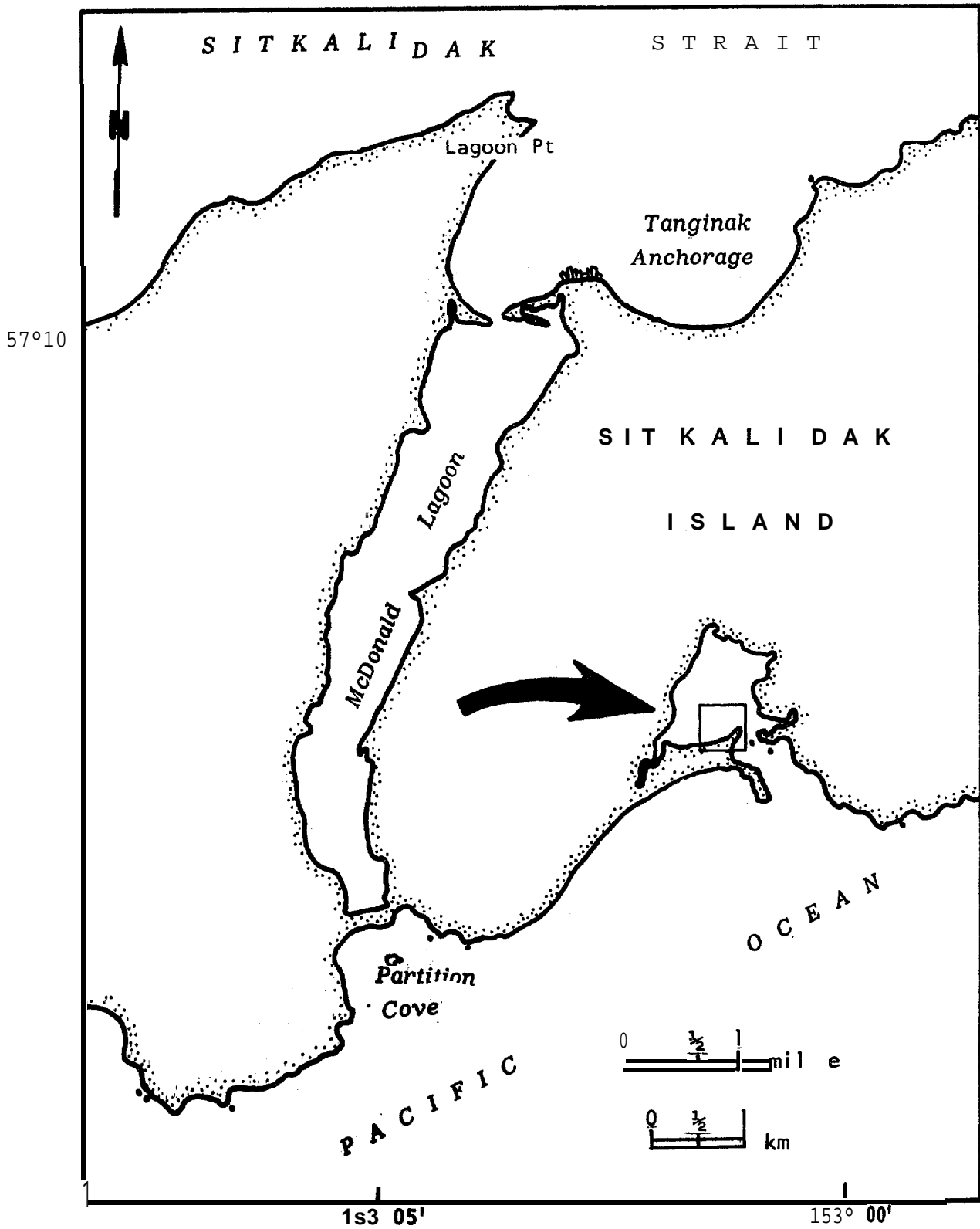


Figure 112. South Sitkalidak Lagoon site.



Figure 113. South Sitkalidak Lagoon, General view of sampling area showing mud flats.

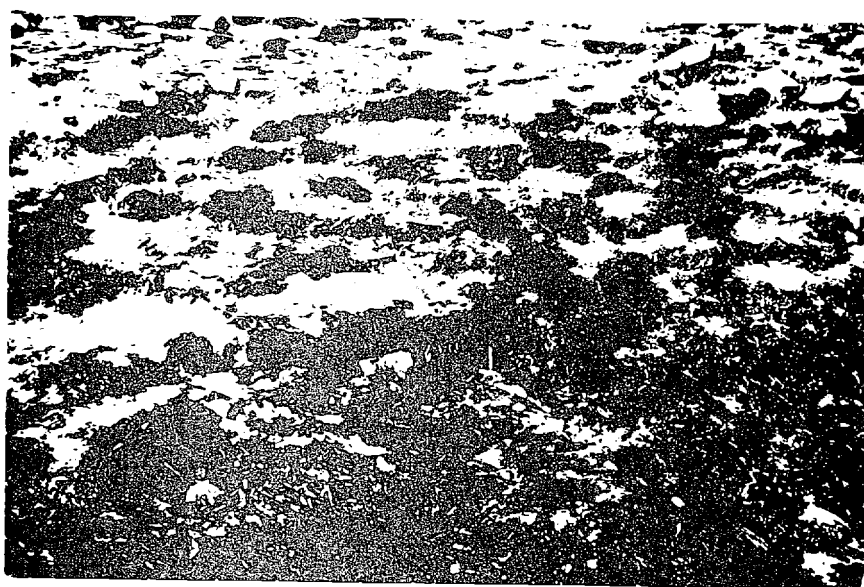


Figure 114. South Sitkalidak Lagoon. General view of sampling area showing algal cover and flowing brackish water at low tide.

Table 29. --Number of organisms collected in 1-liter cores (10 cm x 10 cm) at South **Sitkalidak** Lagoon on 19 May 1976.

Transect meter number	Elevation (m)	Replicate	Depth of core	Organism	No. of organisms
80	1.00		0-10 cm	Oligochaeta	184
				Eteone longa	8
				<u>Turtonia occidentalis</u>	96
				<u>Fabricia sabella</u>	96
				Polychaeta	8
				Nemertea	8
95	0.98		0-10 cm	Oligochaeta	22
				Oligochaeta	2
				<u>Turtonia occidentals</u>	3
				<u>Fabricia sabella</u>	19
				Amphipoda	1
65A1	0.98	1	0-10 cm	Oligochaeta	688
				<u>Turtonia occidentals</u>	32
				<u>Fabricia sabella</u>	288
				<u>Nephtys caeca</u>	1
65A2	0.98		10-20 cm	Oligochaeta	68
				<u>Turtonia occidentals</u>	4
				<u>Fabricia sabella</u>	12
65B	0.98	2	0-10 cm	Oligochaeta	248
				Oligochaeta	56
				<u>Turtonia occidentals</u>	24
				<u>Fabricia sabella</u>	376
				<u>Macoma balthica</u>	1
110	0.95		0-10 cm	Oligochaeta	304
				<u>Turtonia occidentals</u>	48
				<u>Fabricia sabella</u>	168
				<u>Nephtys caeca</u>	1
				<u>Macoma balthica</u>	1
				Archiannelida	8
125A1	0.88	1	0-10 cm	Oligochaeta	864
				<u>Turtonia occidentals</u>	8
				<u>Fabricia sabella</u>	60
				Amphipoda	8
				Archiannelida	16
125A2	0.88		10-20 cm	Oligochaeta	26
				<u>Fabricia sabella</u>	3

Table 29. --Continued.

Transect meter number	Elevation (m)	Replicate	Depth of core	Organisms	No. of Organisms
125B	0.88	2	0-10 cm	Oligochaeta	280
				<u>Fabricia sabella</u>	28
				<u>Polychaeta</u>	24
				Archannelida	16
5A	0.88	1	0-10 cm	Oligochaeta	848
				Oligochaeta	48
				<u>Turtonia occidentals</u>	48
				<u>Fabricia sabella</u>	48
				<u>Polychaeta</u>	48
				<u>Macoma balthica</u>	1
				Nemertea	16
5B	0.88	2	0-10 cm	Oligochaeta	184
				Oligochaeta	528
				<u>Fabricia sabella</u>	136
50A1	0.85	1	0-10 cm	Oligochaeta	1,680
				Oligochaeta	48
				<u>Turtonia occidentals</u>	32
				<u>Fabricia sabella</u>	656
				<u>Nephtys caeca</u>	1
50A2	0.85		10-20 cm	Oligochaeta	176
				<u>Fabricia sabella</u>	32
SOB	0.85	2	0-10 cm	Oligochaeta	64
				<u>Turtonia occidentals</u>	12
				<u>Fabricia sabella</u>	136
				Nemertea	4
35A1	0.70	1	0-10 cm	Oligochaeta	1,008
				<u>Turtonia occidentals</u>	48
				<u>Fabricia sabella</u>	143
				<u>Nephtys caeca</u>	1
35A2	0.70		10-20 cm	Oligochaeta	24
				<u>Turtonia occidentals</u>	16
				<u>Fabricia sabella</u>	8
				Polychaeta	8
35B	0.70	2	10-20 cm	Oligochaeta	496
				<u>Turtonia occidentals</u>	96
				<u>Fabricia sabella</u>	48
				<u>Nephtys caeca</u>	1

Table 29. --Continued

Transect meter number	Elevation (m)	Replicate	Depth of Core	Organism	No. of Organisms
140	0.67		0-10 cm	Oligochaeta	96
19A	0.67	1	0-10 cm	Oligochaeta	2,608
				<u>Fabricia sabella</u>	368
				Nemertea	16
19B1	0.67	2	0-10 cm	Oligochaeta	1,056
				Oligochaeta	112
				<u>Fabricia sabella</u>	208
19B2	0.67		10-20 cm	Oligochaeta	5
				Oligochaeta	1
				Polychaeta	1
				Nemertea	1
25	0.49		0-10 cm	Oligochaeta	736
				Oligochaeta	96
				<u>Turtonia occidentals</u>	32
				Amphipoda	32
				<u>Macoma calcera</u>	1
155	0.18		0-10 cm	Oligochaeta	376
				<u>Turtonia occidentals</u>	40
				<u>Fabricia sabella</u>	56
				<u>Etone longs</u>	40
				Nemertea	8
				<u>Mytilus edulis</u>	1

SUMMARY

An aerial survey indicated that intertidal biological cover is heaviest in the northeastern and southern sections of the region around Kodiak Island. Therefore, special care should be taken to protect these areas from oil pollution.

Bedrock substrate characterizes 48% of Kodiak's intertidal area.

The distributions and abundances of principal intertidal plants and invertebrates are described at about 40 sites in the Kodiak Island region. Littoral zonation in the region is compared with published descriptions of areas elsewhere in the north Pacific and with Stephenson and Stephenson's universal scheme.

Comparison of species composition and biomass on adjacent transects at two sites indicated that spatial variability within sites was high, obscuring seasonal patterns and confounding between-site comparisons. Nevertheless, when sites were classed according to exposure, topography, and substrate, exposed flat bedrock beaches appeared to have lower species number and biomass than other stable bedrock beaches. Rhodomela larix, Phyllospadix serrulatus, and Gigartina sp. were found on exposed flat bedrock habitats while Rhodomenia palmata, Spongomorpha sp., and Katharina tunicata were more common in nonflat habitats. Mytilus edulis appeared to reach highest densities in protected or partly protected areas and were uncommon at exposed locations.

Densities of biota were lower at sites affected by frequent physical disturbance such as scouring by sand or gravel and unstable substrates (cobble and boulders) at exposed sites.

Benthic kelps were widely distributed and high in biomass in the region of Kodiak island. Very large individuals of Nereocystis luetkeana and Laminaria dentigera were recorded. The total biomass of Fucus spp. on rocky beaches in the Kodiak Island region was estimated to be 3×10^7 to 1×10^8 kg.

Diversity indices did not reveal any clear patterns in species diversity of plants or animals within or between sites.

Correlation analysis was of limited use in detecting species associations.

Biomass on gravel and sand beaches was relatively small, with pelecypod molluscs, polychaete worms, and amphipods the most common organisms. On mud flats the distribution of organisms was patchy. Polychaete and oligochaete worms were the most common species at the single muddy quantitative study area.

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Howard Sears made the aerial survey of habitat **distribution.**

Alexander Hoke developed the computer format and programs. The analyses were completed by Jean Grimm; card punching was done by Alice Tipton and Terry **Slavin**. Ted **Merrell** helped to direct and develop the overall program in his capacity as co-principal investigator.

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FINAL REPORT
FOR
SORTING AND IDENTIFICATION OF INTERTIDAL SAMPLES

Contract # 03-7-208-35135

Research Unit 79

Work Accomplished and Report Prepared by

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August 30, 1978

PART I - INTRODUCTION

This report summarizes the stations and taxonomic problems encountered in this service contract. It **is** divided into three parts: Introduction, Station List and **Taxonomic** Section. The **taxonomic** section is further divided in a discussion of significant **taxonomic** problems, a species list, and the major references used for determination of the group. The **taxonomic** order is **of** convenience and not strictly hierarchical.

Within the past three years well over 2,000 samples from approximately 80 localities were analyzed. The species composition, numbers of individuals, and in many cases wet and dry weights were determined. **Recognizing the constraints of collecting, two groups in particular, Algae and Annelids, did not** survive the preservation and shipping. The Algae was often fragmented and generally **in** poor condition. The other groups were found **in** good condition in most instances.

The systematic quality of the entire study is excellent. Those groups that posed taxonomic problems and were in sufficient abundance were either sent *out* for examination by recognized authorities or compared by staff members with **well** identified material in other museums. It **shou]d** be recognized, however, that **in a study of this magnitude some misidentifications will inevitably occur.** In house spot checks on identifications indicate that errors in identification and in quantitative analysis were less than one half of one (1%) percent.

All of the sample analyzes **have** been completed and submitted. The vouchers will be shipped **in** the near future. The submission of this final report should complete the contract.

PART II - LISTING OF SAMPLES PROCESSED BY SORTING CENTER

Localities of Samples Processed by Sorting Center - 1974

<u>Locality</u>	<u>Collection Date</u>	<u>No. of Stations</u>
Dayville (Port Valdez)	28 April - 31 July	3
Anchor Cove	8 September	8
Anchor Bay	September	17
Squirrel Bay (nested quad.)	13 September	13
Ocean Cape site	October	1
Boswell Bay	September	46
Katalla	October	15
McLeod Harbor	September	27
Middleton Mud	October	10
Squirrel Bay	September	32
Yakutat, Yakataga	October	42
Zaikof	September	10
Port Valdez	September	20

PART II (Cont'd.)

Localities of Samples Processed by Sorting Center - 1975

<u>Local i t y</u>	<u>Collection Date</u>	<u>No. of Stations</u>
Akun	18 July	27
Amak	19 July	19
Anchor Cove	21 April	20
Day Harbor	3 September	41
Boswell Bay	1 May	22
Boswell Bay	9 September	33
Cape Pierce	21 July	17
Chirikof	27 May	38
Chirikof	10 August	30
Crooked Island	20 July	16
Walrus Island	20 July	1
Katalla	28 April	34
Katalla	9 September	36
Kayak	9 September	19
Latouche	29 April	24
Latouche	4 September	' 44
Makushin	25 July	23
Makushin	13 August	21
McLeod Harbor	17 April	17
McLeod Harbor	5 September	31
Middleton mud	28 April	10
	6 September	9
Mordvinoff	24 July	8

PART II (Cent'd.)

Urilia Bay	24 July	3
Nukshak	24 May	24
	8 August	31
Otter Island	16 August	39
Port Dick	21 May	36
	6 August	22
Port Edward	22 July	38
Port Moller	23 July	7
Port Etches	27 April	15
Constantine	27 April	1
Port Valdez	24 July	40
Port Valdez	May	40
Spectacle	25 May	34
	11 August	25
Sud Island	23 May	24
Barren Island	23 May	1
Sud	8 August	50
Sundstrom	17-28 May	33
	August	47
Three Saints Bay	29 May	32
	7 August	16
Yakutat	10 June	15
Yakutaga	11 June	41
Ocean Cape (Yakutaga)	4 September	21

PART II (Cent'd.)

Yakutaga	5 September	42
Zaikof	25 August	44
Zaikof	26 September	40
St. George	July - August	10
Bristol Bay	July - August	1
Walrus Island	July - August	2
Sud Island	July - August	2
Makushin Bay	July - August	2
Captain's Bay	July -August	2
Zaikof Bay (nested quad.)	September	6
McLeod (nested quad.)	September	4
Zapadni	15 August	41

PART 11 (Cent'd.)

Localities of Samples Processed by Sorting Center - 1976

<u>Locality</u>	<u>Collection Date</u>	<u>No. of Stations</u>
Woody Point	9 August	29
Stuart Island	8 August	15
Cape Lupin	17 June	21
Cape Glazenak	16 June	15
Eider Point	14 June	30
Otter Island	12 June	22
Dolina Point	14 May	18
Cape Kaguyak	12 May	11
Kayak	19 April	17
Egg Island	15 April	27
Golovin	11 August	13
Hook Point	13 April	18
Sledge	7 August	6
Boswell Bay	14 April	32
Bluff site 2	12 August	8
Rocky Point	11 August	6
Cape Denbigh	10 August	12
Cape Woolley	13 August	10
Cape Sitkinak	13 May	16
Low Cape	17 May	11
Lagoon Point	15 May	41
Izembeck #1	15 June	41
Izembeck #2	15 June	12
Izembeck #3	16 June	14

PART II {Cent'd.}

Cape Nome	14 August	7
Tolstoi Point	9 June	2
Kanak Island	17 April	23
Softuk spit	18 April	14
Zapadni	10 June	8

1974 Samples	244
1975 Samples	1,371
1976 Samples	<u>499</u>
Total	2,114

PART III - TAXONOMIC SECTION

PORIFERA

Taxonomic Problems:

The species Halichondria panicea, as currently understood, is an extremely plastic species occurring from the intertidal through shelf depths. This species may eventually be separated into several species.

Species List:

Halichondria panicea

Leucandra heathi

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CNIDARIA - HYDROZOA

Taxonomic Problems:

Hydrozoa were identified in all cases where the material was in adequate condition and amount.

Species List:

Halecium **sp.**

Bougainvilliidea

Clava cf. multiforms

Endendrium rameum

Endendrium annulatum

Sertularella tricuspidata

Sertularella rugosa

Sertularia albimaris

Abietinaria felicula

Abietinaria variabilis

Tubularia **simplex**

Obelia longissima

Obelia geniculata

Thuiaria **sp.**

Clava **multiforms**

References:

Fraser, C.M. 1937. **Hydroids** of the Pacific Coast of Canada and the United States. Univ. of Toronto Press. Toronto. 207 p.

Naumov, D.V. 1969. Hydroids and Hydromedusae of the USSR. U.S. Dept. of Commerce, Springfield, Va. 22151.

Torrey, H.B. 1902. The **Hydroids** of the Pacific Coast of North America. Univ. Calif. Press in **Zool.1:104.**

CNIDARIA - SCYPHOZOA

Taxonomic Problems:

The few **scyphozoa** presented no difficulty in determination as presented.

Species List:

Haliclystus auricula

Haliclystus sp.

Cyanea capillata

Paloclistus sp.

References:

Naumov, S.V. 1961. Scyphomedusae of the Seas of the USSR (In Russian).

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Kramp, P.L. 1961. Synopsis of the Medusae of the World. Syndics of the Cambridge University Press, London.

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Stiasny, G. and li. van der Maaden. 1943. On Sycphomedusae from the Okhotsk and Kamchatka Seas with some criticism of the general Cyanea and Desmonema (In German). Zool.Jahr. ABT, Fur Syst. Geog. and Biol. Bd.76/3:227-266.

CNIDARIA - ANTHOZOA

Taxonomic Problems:

Actinarians were not determined in this study. Identification of material in Alaska requires examination of internal structures, from material relaxed and carefully preserved. Identification from external features is not possible **in** view of the lack of knowledge of Alaskan fauna.

Species List:

Eunephthya rubiformis

References:

Gaevskaia, N.S. ed. 1948. Keys to the Fauna and Flora of the Northern Seas of the USSR. Governmental Publications of Socialist Science. Vol. 74:1-667.

PLATYHELMINTHES

Taxonomic Problems:

Platyhelminthes were not determined in this study. Approximately two hundred individuals from 1974-1976 were examined and in all cases were juveniles or the reproductive apparatus was insufficiently developed to determine genera.

RHYNCHOCOELA

Taxonomic Problems:

Nemerteans were not determined except in a few cases where fragmentation had not occurred.

Species List:

Cerebratulus sp.

Emplectonema gracile

References:

Coe, W.R. 1940. Revision of the Nemertean Fauna of the Pacific Coasts of North, Central and Northern South America. Allan Hancock Pac. Expedition. 2(13):247-323.

PRIAPULIDA

Taxonomic Problems:

None

Species List:

Priapulus caudatus

References:

Gaevskaia, N.S. ed. 1948. Keys to the Fauna and Flora of the Northern Seas of the USSR. Governmental Publications of Socialist Science. Vol. 74:1-667.

SIPUNCULA and ECHIURA

Taxonomic Problems:

None.

Species List:

Sipuncula

Phascolosoma agassizii

Echiura

Bonelliopsis alaskana

Echiurus echiurus alaskana

References:

Stephen, A.C. and S.J. Edmonds. 1972. The Phyla Sipuncula and Echiura. Trustees of the British Museum (Natural History), London. pg. 1-732.

MOLLUSCA

Taxonomic Problems:

Mollusca are for the most part well described. The Alaskan fauna is perhaps the best known of any phylum. Those species that presented taxonomic problems for the most part have been resolved by Nora Foster through comparison with material at the U. S. National Museum of Natural History, Los Angeles County Museum and at the California Academy of Sciences. In those groups where resolution of the species has not been possible the specimens have not been identified to species.

Species List:

Aplacophora

Chaetoderma robusta

Polyplacophora

Cyanoplax dentiens

Ischnochiton albus

Dendrochiton thamnoporus

Katharina tunicata

Lepidochitona sharpei

Mopalia ciliata

Mopalia cirrata

Mopalia laevior

Mopalia lignosa

Mopalia mucosa

Placiphorella rufa

Schizoplax brandtii

Tonicella lineata

Tonicella marmorea

Tonicella rubra

Spongioradsia aleutica

Pelecepod

Astarte alaskensis

Axinopsida serricata

Clinocardium californiensis

Clinocardium ciliatum

Clinocardium nuttallii

Cyrtodaria kurriana

Dacrydium sp.

Entodesma saxicolum

Hiatella arctica

Kellia laperousi

Macoma balthica

Macoma brota

Macoma lama

Macoma moesta

Macoma obliqua

Megacrenella columbiana

Modiolus modiolus

Musculus discors

Musculus niger

Musculus olivaceus

Musculus vernicosus

Mya arenaria

Mya elegans

Mysella planata

Mysella tumida

Mytilus edulis

Nucula tenuis

Neaeromya compressa

Nuculana pernula

Pododesmus machrochisma

Protothaca staminea

Saxidomus gigantea

Serripes groenlandica

Siliqua alta

Spisula polynyma

Telina leutea

Thracia sp.

Turtonia occidentals

Gastropod

Acanthodoris sp.

Acmaea mitra

Acmaea rosacea

Acmaea sybaritic

Admete couthouyi

Alvinia aurivilli

Alvinia compacta

Amauropsis islandicus

Amphissa columbiana

Aquilonaria turneri

Balcis columbiana

Balcis micrans

Balcis randolfi

Barleeia haliotiphila

Barleeia subtenuis

Bittium munitum

Buccinum baeri

Bulbus fragilis

Calliostoma ligature

Cerithiopsis stejnegeri

Cerithiopsis stephansae

Cingula aleutica

Cingula katharinae

Collisella digitalis

Collisella fenestrata

Collisella ochracea

Collisella pelta

Collisella "persona

Collisella scutum

Collisella cf. strigiatella

Crepidula nummaria

Crepidatella lingulata

Cylinchna alba

Cylinchna occulta

Cryptobranchia alba

Cryptobranchia concentrica

Diaphana brunnea

Diaphana minuta

Fusitriton oregonensis

Granulina margaritula

Haloconcha reflexa

Homalopoma engbergi

Lacuna carinata

Lacuna marginata

Lacuna variegata

Lacuna vineta

Lepeta caeca

Lirularia succintus

Littorina aleutica

Littorina scutulata

Littorina squalida

Margarities beringensis

Margarities helacinus

Margarities pupillus

Mitrella gouldi

Mitrella rosacea

Mitrella tuberosa

Moellaria costulata

Moellaria drusiana

Moellaria quadrae

Nassarius mendicus

Natica clausa

Neptunea heros

Neptunea lyrata

Nucella canaliculata

Nucella lamellosa

Nucella lima

Ocenebra interfossa

Odostomia sp.

Onchidella borealis

Oneopota tabulata

Polinices pallida

Puncturella cucullata

Puncturella noachina

Retusa sp.

Searlesia dira

Siphonaria thersites

Solariella sp.

Trichotropsis cancellata

Trichotropsis insignis

Trophanopsis multicostatus

Turbonilla sp.

Urosalpinx luri da (ocenebra)

Velutina velutina

Volutharpa ampulacea

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Wash.: Sea & Shore. 102 pp., 40 col. pls., 3 figs.

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ANNELIDA - POLYCHAETA

Taxonomic Problems:

In general all **polychaetes** are correctly identified to genera; because of the problem of fragmentation there may be errors **in** some of the specific determinations. Representatives of 28 problem species were confirmed by George Mueller by comparison **at** the **Allan** Hancock Foundation, Los Angeles, California. Additional problems are detailed below:

Family Phyllodocidae

Anaitides mucosa and A. maculata are determined by color patterns. These patterns do not appear to be **consistent in** intertidal specimens. A. mucosa as collected from **subtidal** grab samples **is** clearly separable from A. macula. The intertidal specimens are closer to A. maculata and as a consequence are called Anaitides maculata. A similar problem in intergradation occurs between Eulalia viridis and E. quadrioculata. The **decision** was to report all of the specimens as Eulalia quadrioculata.

Family Syllidae

All species' determinations of Autolytus are questionable. Neither the review of the Genus by Imajima nor the revision by Gidholm appears adequate for Alaskan material.

The genus Typosyllis **is** not well understood. Of the species reported T. pulchra, T. alternata and T. adamantea **fit** their descriptions and were confirmed at the **Allan** Hancock Foundation with no problems. The other species reported either do not fit their descriptions well or are insufficiently described for positive determination.

Syllid epitokes are not described for Alaskan waters.

Taxonomic Problems (Cent' d.)

Family Nereidae

There is a problem with Nereis pelagica and Nereis zonata determinations. It appears that a third species falling between the above **is** present and currently **is undescribed**. This species may have been assigned to either of the above species as well as **being reported as** Nereis sp. **Sexually mature forms, heteronered, are not described for** Alaska.

Family Spionidae

The species of Polydora and Boccardia in the 1974 samples were poorly identified.

Family Cirratulidae

The species Chaetozone setosa and Cirratulus cirrata are correct. The species of Tharyx cannot be determined.

Family Capitellidae

The determinations of Capitella capitata may contain other **species**. When **capitellids** were determined to be Heteromastus they are correct.

Family Terebellidae

This family preserves very poorly. As a consequence specific determinations may not always be correct.

Taxonomic Problems (Cont'd.)

Family Maldanidae

Specimens of this family generally fragment while identification requires whole specimens. The determinations are generally correct but may **contain fragments of additional unreported species.**

Family Ophelidae

Ammotrypane is no longer correct and should be changed to Ophelina. The trivial name remains the same.

Family Sabellidae

Species determinations of Chone and Fabricia are questionable. Available literature is inadequate for the positive determination of Alaskan material.

Species List:

Polynoidae

Arctonoe pulchra
Arctonoe vittata
Gattyana ciliata
Gattyana "treadwelli"
Halosynda brevisetosa
Harmathoe extenuata
Harmathoe imbricata
Hesperone sp.
Lepidonatus squamatus
Peicidice aspera
Pholoe minuta

Chrysopetalidae

Dysponetus pygmaeus
Paleanotus bellis
Phyllodocidae
Anaitides groenlandica
Anaitides maculata
Anaitides mucosa
Eteone longis
Eulalia bilineata
Eulalia quadrioculata
Eulalia viridis
Genetyllis castanea

Species List (Cent'd.)

Mysta barbata

Notophyllum tectum

Syllidea

Autolytus cornutus

Autolytus prismaticus

Autolytus trilineatus

Brania brevipharyngea

Eusyllis assimilis

Eusyllis bloomstrandii

Exogone gemmifera

Exogone lourei

Exogone molesta

Exogone verrugera

Parasphaerosyllis sp.

Sphaerosyllis brandhorsti

Sphaerosyllis hystrix

Sphaerosyllis pirifera

Syllides japonica

Typosyllis a. adamantea

Typosyllis alternata

Typosyllis armillaris

Typosyllis elongata

Typosyllis harti

Typosyllis hyalina

Typosyllis pulchra

Typosyllis stewarti

Typosyllis variegata

Neriedae

Neries grubei

Neries pelagica

Neries procera

Neries vexillosa

Neries zonata

Platyneries bicanaliculata

Nephtyidae

Nepthys caeca

Nepthys ciliata

Nepthys cornuta

Nepthys longosetosa

Sphaerodoridae

Sphaerodorum gracilis

Sphaerodopsis minuta

Sphaerodopsis sphaerulifer

Glyceridae

Glycera capitata

Goniadae

Goniada annulata

Glycinde armigera

Glycinde picta

Onuphidae

Onuphis geophiliformis

-iridescent

Onuphis stigmatis

Species List (Cont'd.)

Eunicidae

Eunice kobiensis

Eunice valens

Lumbrineridae

Lumbrinaries inflata

Lumbrinaries similabris

Lumbrinaries zonata

Dorvilleidae

Protodorvillea sp.

Orbinidae

Haploscoloplos elongatus

Haploscoloplos panamensis

Naineries laevigata

Naineries quadricuspida

Scoloplos armiger

Paraonidae

Aricidea suecica

Paraonis gracilis

Spionidae

Boccardia columbiana

Boccardia natrix

Boccardia proboscidea

Laonice cirrata

Nerine cirratulus

Polydora caulleryi

Polydora ciliata

Polydora quadrilobata

Polydora socialis

Prionospio cirrifera

Prionospio malmgreni

Pygospio californica

Pygospio elegans

Rhynchospio sp.

Spiophanes bombyx

Spiophanes cirrata

Megelonidae

Magelona sp.

Chaetopteridae

Chaetopterus variopedatus

Cirratulidae

Chaetozone setosa

Cirratulus cirratus

Tharyx sp.

Flabelligeridae

Brada villosa

Flabelligera affinis

Pherusa papillata

Scalibregmidae

Scalibregma inflatum

Species List (Cent'd.)

Opheliidae

Ammotrypane aulogaster

Armandia brevis

Ophelia limacina

Thoracophelia micronata

Capitellidae

Capitella capitata

Heteromastus filiformis

Arenicolidae

Abarenicola pacifica

Arenicola glacialis

Sabellariidae

Idanthyrus armatus

Oweniidae

Myriochele heeri

Owenia fusiformis

Maldanidae

Axiothella rubrocincta

Maldane sarsi

Maldanella robusta

Nichomanche personata

Praxillella affinis

Pectinariidae

Cistenides brevicoma

Cistenides granulata

Ampharetidae

Ampharete arctica

Asabellides sibirica

Glyphanostomum pallescens

Terebellidae

Nicolea zostericola

Polycirrus caliendrum

Polycirrus medusa

Thelepus hematus

Trichobranchidae

Terebellides stroemii

Sabellidae

Amphiglena pacifica

Chone cincta

Chone gracilis

Fabricia crenicollis

Fabricia minuta

Fabricia pacifica

Fabricia sabella

Laonome sp.

Potamilla neglecta

Pseudopotamilla reniformis

Schizobranchia insignis

Species List (Cont'd.)

Serpulidae

Crucigera zygophora

Dexiospira spirillum

Serpula vermicularis

Spirorbis granulatus

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of the **USSR**). (In Russian). **Akad. Nauk SSSR**, Keys to the Fauna
of the SSSR **56:1-433** (translated, 1965 by Israel Program Scientific
Translating, Jerusalem).

References (Cent'd.]

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4(2) **Polychaeta: Sabellidae to Serpulidae**. With additions to the
British marine **Polychaeta** during the publication of the monograph:
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Sound and adjacent waters. Univ. of Wash. press, Seattle. Library
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Region 1. **Aphroditidae** through Trochochaetidae. U.S. Nat.
Mus., Bull. 227:1-356.
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Polychaeta), including descriptions of new species, and redescription
of the pelagic Podarmus plea Chamberlain (Polynoidae). U.S. Nat.
Mus., Proc. 118(3525):155-208.
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described from the Pacific Coast of the United States and Canada.
Proc. of the Taxonomic Standardization Program. 5/3:25-38.
- Uschakov, P.** 1955a. (**Polychaetous** annelids of the Far Eastern Seas
of the USSR). (In Russian). Akad. Nauk SSSR, Keys to the Fauna
of the SSSR 56:1-433 (translated, 1965 by Israel Program Scientific
Translating, Jerusalem).

References (Cent' d.)

- Uschakov, P.** 1972. (**Polychaeta** 1. **Polychaetes** of the suborder **Phyllodociformia** of the Polar **Basin** and the northwestern part of the Pacific). (In Russian). Akad. Nauk **SSSR. Zool.** Inst. Fauna of the **SSSR, n.s.** 102, 271 pp. (translated 1974 by the Israel Program for Scientific Translation, Jerusalem).
- Wells, G.P.** 1959. The genera of **Arenicolidae (Polychaeta)**. **Proc. Zool. Soc. London** **133:301-314**.

ANNELIDA - ARCHIANNELIDA

Taxonomic Problems

None.

Species List:

Saccocirrus sp.

References:

Fauchald, K. 1977. The **Polychaete Worms** Definitions and Keys to the Orders, Families and Genera. Natural History Museum of Los Angeles County, S. S. 28:1-188.

ANNELIDA - OLIGOCHAETA

Taxonomic Problems:

The majority of **Oligochaetes** found were not sexually mature and could not be identified to genus. Additionally, most specimens are in the family Enchytraeidae, the marine representatives of which are **simply not known anywhere.**

References:

Brinkhurst, R.O. and B.G.M. Jamieson. 1971. Aquatic **Oligochaeta** of the **World**. Oliver & Boyd. Edinburgh. University of Toronto Press. 860 p.

ARTHROPODA - PYCNOGONIDA

Taxonomic Problems:

Pycnogonids were identified from original sources including those listed below until mid-1975 when an in-house key was constructed. Juvenile pycnogonida are undescribed for Alaska.

Species List:

Achelia spinosa

Achelia chelata

Ammonothea alaskensis

Ammonothea gracilipes

Ammonothea latifrons

Ammonothea pribilofensis

Nyphon grossipes

Phoxichilidium femoratum

References:

Cole, L.J. 1904. Pycnogonida of the West Coast of North America. Harri man Alaska Exped. 10:249-298.

Hedgpeth, J.W. 1941. A Key to the Pycnogonida of the Pacific Coast of North America. Trans. San Diego Soc. Nat. Hist. 9:253-264.

Hedgpeth, Joel W. 1949. Report on the Pycnogonida Collected by the ALBATROSS in Japanese Waters in 1900 and 1906. Proc. of the U.S. Nat. Mus., Vol. 98, No. 3231.

Hilton, W.A. 1942. Pycnogonids from Allan Hancock Exped. Allan Hancock Pacific Expeditions, 5(9):277-339.

References (Cont'd.)

- Lozina-Lozinskii, L.K.** 1933. **Pantopoda of the Eastern Seas of the USSR** (In Russian). **Issled. Mor. SSSR. 17:43-80.**
- Sars, G.O.** 1891. **Zoology-Pycnogonidea.** The Norwegian North-Atlantic Expeditions 1876-1878. **Grondahl & Son, London.**
- Shimkevich, V.M.** 1929-30. **Mnogokolenchatye (Pantopoda).** IZD-V0. Akad Nauk SSSR. 555 p.

ARTHROPODA - CRUSTACEA - COPEPODA

Taxonomic Problems:

Marine **Harpacticoida** are not described for Alaskan waters.

Calanoida Presented no problems in determination.

Species" List:

Calanus cristatus

Calanus plumchrus

Metridia lucens

References:

Brodkii, K.A. 1950. **Calanoida** of the Far Eastern Seas and Polar Basin of the USSR. **Izdatel'stvo Akademii Nauk SSSR, Moskva** Leningrad. pp. 1-440.

ARTHROPODA - CIRRIPIEDIA

Taxonomic Problems:

A reported **undescribed Chthamalus** from the Bering Sea was not found in the material from **this** study. All of the **Chthamalus** found appeared to be only **C. dalli**. The genus **Balanus** presented no problems.

Species List:

Chthamalus dalli

Balanus balanoides

Balanus balanus

Balanus cariosus

Balanus crenatus

Balanus glandula

Balanus nubilis

Balanus rostratus

References:

Pilsbry, H.A. 1916. The **Sessile Barnacles (Cirripedia)** contained in the Collections of the U.S. National Museum. Bull. U.S. Nat'l. Mus. 93:1-366.

ARTHROPODA - CRUSTACEA - ISPODA

Taxonomic Problems:

The Asellota is not a well known group in the North Pacific. The genera Ianiropsis and Munna are correct. The determined species **are** the "best fit" to those described in the literature. Synidotea ritteri may represent an undescribed species or variation.

Species List:

Anthuridae

Cryptothir balani

Dynamenella glabra

Dynamenella sheareri

Exosphaeroma amplicauda

Exosphaeroma media

Gnori mosphaeroma oregonensis

Idotea fewkesi

Ianiropsos k. kincaida

Ligia pallasii

Munna chromatocephala

Munna stephensis

Bopyridae

Pentidotea wosensenskii

Synidotea pettiboneae

Synidotea picta

Synidotea ritteri

Saduria entomon

Sphaeromatidae

References:

George, **R.Y.** and J. -O. Stromberg. 1968. Some New Species and New Records of Marine Isopods from San Juan Archipelago, Washington, U. S. A. Crustacean. **14:225-254.**

Gurjanova, E. 1933. Contributions to the **Isopoda** Fauna of the Pacific Ocean. I. New Species of **Valifera** and **Flabellifera**. **Explor.** of the Seas of the U. S. S. R. , **Institut Hydrobiologi.** Leningrad. no. **17:87-106.** II. New Species of **Gnathiidea** and **Asellota**. **Ibid.** no. **19:79-91.** (Russian and English texts.)

Hatch, **M.H.** 1947. The **Chelifera** and **Isopoda** of Washington and adjacent regions. Univ. of Wash. **Publ. in Biol.** **10(5):155-274.**

Menzies, **R.J.** 1950. The Taxonomy, Ecology, and Distribution of Northern California **Isopods** of the Genus **Idothea** with the Description of a New **Species.** **Wasmann Journ. Biol.** **8:155-195.**

Menzies, R.L. and **M.A. Miller.** 1972. Systematic and zoogeography of the genus **Synidotea** (**Crustacea: Isopoda**) with an account of Californian species. Smithsonian Contributions to Zoology. No. 102. Washington, **D.C.**

Richardson, H. 1905. Monograph on the **isopods** of North America. Bull. U. S. Nat'l. Mus. **54:1-727.**

Schultz, **G.A.** 1969. The marine **isopod** crustaceans. Wm. C. Brown Co. Dubuque, Iowa. 359 p.

Wolff, T. 1962. The systematic and biology of **Bathyal** and **abyssal Isopoda Asellota.** **Galathea** Report. **6:7-320.**

ARTHROPODA - CRUSTACEA AMPHIPODA

Taxonomic Problems:

The monographs of Barnard and Gurianova are quite complete for the North Pacific and Bering Sea. The taxonomic problems involving species commonly encountered in this study were examined by J. L. Barnard and resolved. Those not resolvable were reported to the lowest possible taxon determinable with accuracy.

Species List:

Caprellidea

Caprella christibranchium

Caprella sp.

Gammaridea

Accedomoera sp.

Allorchestes anceps

Allorchestes angustus

Allorchestes angustus carinatus

Allorchestes moleolus

Amphithoe brevipes

Amphithoe delli

Amphithoe lindbergi

Amphithoe rubricata

Amphithoe rubricatoides

Anisogammarus locustoides

Anisogammarus subcarinatus

Anonyx sp.

Aoroides columbiae

Calliopiella pratti

Corophium sp.

Eonaustorius washingtonianus

Ericthonius sp.

Heterophoxus oculatus

Hyale grandicornis

Ischyrocerus anguipes

Ischyrocerus krascheninikovi

Jassa pulcella

Melita sp.

Metopella nasuta

Metopelliodes sp.

Najna conciliorum

Odius carinatus

Oligochinus lighti

Orchomene lepidula

Orchomene minuta

Onisimus (Ps.) littoralis

Species List (Cent'd.)

Parallorchestes ochtensis

Paramoera carlottensis

Paramoera columbiana

Paraphoxus sp.

Paraphoxus spinosus

Parapleustes johanseni

Parapleustes nautilus

Parapleustes pugettensis

Photis brevipes

Photis reinhardi

Photis spasskii

Pleustes panopia

Pleustes panoplus

Pleusymptes sp.

Polycheria osbornzi

Pontogeneia kondakoui

Stenopleustes glaber

Stenopleustes siberotobois

Stenopleustes suberitobius

Stenopleustes uncigera

Sympleustes suberitobius

References:

Barnard, J.L. 1954. Marine Amphipoda of Oregon. Oregon State Monog.

Zool. No. 8, 103p.

Barnard, J.L. 1969. Gammaridean Amphipoda of the Rocky Intertidal of

California: Monterey Bay to La Jolla. Bull. U.S. Nat. Mus. 258:230 p.

Barnard, J.L. 1969. The families and genera of marine gammaridean

amphipods. U.S. Nat'l. Mus. Smithsonian Inst. Bull. 27:1-535.

Gurianova, E.F. 1951. (Amphipods of the Seas of the USSR and Adjacent

Waters (Amphipoda: Gammaridae)). Opredelitel' po-Faune SSSR. 41.

1029 p. (in Russian)

References (Cent' d.]

- Gurianova, E.F. 1962.** (Amphipods of the Northern Part of the Pacific Ocean. Part I) **Opredeliteli po Faune SSSR. 74. 440 p. (in Russian).**
- Laubitz, D.R. 1970.** Studies on the **Caprellidae (Crustacea, Amphipoda)** of the American North Pacific. Can. Nat'l. Mus. **Sci. Publ. Biol.** Ocean. 1: 1-89.
- Vasilenko, S.V. 1974.** **Caprellids** (sea goats) of the seas of the USSR and **nearby waters.** (in Russian). **Akademiia Nauk SSSR. Zoologicheskii Institut. Opredeliteli po faune SSSR. No. 107. 287 p.**

ARTHROPODA - OTHER PERACARIDA

Taxonomic Problems:

None to the level in which the data is presented.

Species List:

Mysidacea

Archaeomysis grebnitzkii

Neomysis czerniawski

Mysis sp.

Cumacea

Lamprops quadriplicata

Endorella emarginata

Diastylis sulcata

Campylapsis affinis

Cumella sp.

Tanaidacea

Tanais sp.

References:

Banner, A.H. 1947. A Taxonomic Study of the **Mysidacea** and **Euphausiacea** (**Crustacea**) of the Northeastern Pacific. I. **Mysidacea:** Family Lophogastridae Through Tribe **Erythropini.** " Trans. Roy. Can. Inst. 27(57): 347-399.

Banner, A.H. 1948. A Taxonomic Study of the **Mysidacea** and the **Euphausiacea** (**Crustacea**) of the Northeastern Pacific. II. **Mysidacea:** Tribe **Mysini** Through Subfamily **Mysidellinae.** Trans. Roy. Can. Inst. 27(57): 65-125.

References (Cont' d.)

Lang, K.F. 1957. **Tanaidacea** from Canada and Alaska. Contr. Depart.
Pech. Quebec. 52:1-54.

Lomakina, N.B. 1958. (**Cumacean Crustaceans (Cumacea)** of the Seas of
the U.S.S.R.). **Opredeliteli po Faune SSSR.** 66. 301 p. (in
Russian).

Richardson, H. 1905. A Monograph of the **Isopods** of North America.
Bull. U.S. Nat. Mus. 54:727P.

ARTHROPODA - CRUSTACEA - DECAPODA

Taxonomic Problems:

None

Species List:

Caridea

Cranion sp.

Heptacarpus brevirostris

Heptacarpus camtschatica

Anomura

Dermaturus mandtii

Pagurus beringanus

Pagurus hirsutinsculus

Brachyura

Cancer oregonensis

Chionoecetes sp. (Megalops)

Pugettia gracilis

Telmessus cheiragonus

References:

McLaughlin, P.A. 1974. The Hermit Crabs (Crustacea Decapoda, Paguridea) of the Northwestern North America. **Zool. Verhandl. Leiden.** Pg. 396.

Makarov, J.J. 1938. Fauna of the USSR. V. X, No. 3. **Crustacea: Anomura.** **Zool. Institut. Akademii. Nauk. SSSR. Moskva.** pg. 283.

Rathbun, M.J., H. Richardson, S.J. Holmes, and L. J. Cole. 1910. H. A. E. Vol. **Crustacea.** Smithsonian Institution. Wash., **D.C. Publ.** 1997. Pg. 337.

ARTHROPODA - INSECTA

Taxonomic Problems:

Marine Insects of Alaska for the most part are unknown. It was not possible to determine most of the material below family.

Species List:

Staphylinidae

Cicadellidae

Chironomidae

Dolichopodidae

Psyllidae

References:

Usinger, **R.L.** 1956. Aquatic insects of **Calif.** with Keys to North American Genera and **Calif.** Species. Un. of **Calif.** Berkeley press.
Pg. 508.

ECTOPROCTA

Taxonomic Problems:

The **bryozoans** encountered in this set of samples generally posed no **taxonomic problems to the level reported.** **Flustra securifrons** has **not** been reported south of the Bering Str. The other species reported below are relatively well known and described.

Species List:

Alcyonidium disforme

Alcyonidium polyum

Bugula sp.

Clavipora occidentalis

Costazia sercularis

Crisis occidentalis

Dendrobeania murrayana

Encratta loricata

Filicrisia sp.

Flustra securifrons

Flustrella sp.

Flustrella gigantea

Hippodiplosia insulpta

Hippothoa hyalina

Microporella sp.

Microporina borealis

Myrionozoum coarctatum

Tricellaria occidentalis

Tricellaria ternata

References:

- Luge, G.A.** 1975. **Bryozoa** of the Northern Seas of the U.S.S.R.
Zool. Inst., Acad. of Sci. USSR No. 76. pg. 711.
- Osburn, R.C.** 1950. **Bryozoa** of the Pacific Coast of America. Pt. I
Cheilostomata-Anasca. **Allan Hancock Pacific Exped. XIV. Un. of**
So. Calif. Press. Pg. **1-269.**
- Osburn, R.C.** 1952. **Bryozoa** of the Pacific Coast of America. Pt. 11.
Cheilostomata-Ascophora. **Allan Hancock Pacific Exped. XIV. Un.**
of So. Calif Press. Pg. 271-611.
- Osburn, R.C.** 1953. **Bryozoa** of the Pacific Coast of America. Pt. III.
Cyclostomata, Ctenostomata, Entoprocta and addenda, Allan Hancock
Pacific Exped. XIV. Un. of-So. Calif. Press. Pg. 614-841.
- Ross, J.R.P.** 1970. Keys to the Recent **Cyclostome** Ectoprocta of the
Marine Waters of Northwest Washington State. Northwest Science.
Vol. 44 No. 3. Pg. 154-169.

BRACHIOPODA

Taxonomic Problems:

None.

Species List:

Terebratalia transversal

References:

Bernard, **F.R.** 1972. The Living **Brachiopoda** of British Columbia.
Syesis **5:73-82.**

ECHINODERMATA

Taxonomic Problems:

Species of the Asteroid Genera, Henricia and Leptasterias are poorly defined. Some mature and most immature individuals intergrade between the various species within each genera making identification difficult at best. **Holothuroidians** with two exceptions were not identified due to general poor preservation and lack of knowledge of Alaskan material.

Species List:

Asteriidea

Asterias amurensis

Evasterias troschelli

Evasterias Sp.

Henricia sanguinolenta

Henricia sp.

Henricia leviscula

Leptasterias alaskensis

Leptasterias groenlandica

Leptasterias hexactis

Leptasterias leptodoma

Leptasterias camtschatica

Pisaster ochraceous

Pycnopodia helianthoides

Ophuroidea

Ophiophalis aculeata

Species List (cont'd.)

Echinoidea

Strongylocentrotus droebachiensis

Strongylocentrotus pallidus

Strongylocentrotus purpuraceus

Holothuroidea

Cucumaria pseudocurata

Thyonidium pellucidus

References:

- Clark, H.L. 1901. The **Holothurians** of the Pacific Coast of North America. **Zool. Anz.** 24:162-171.
- Clark, H.L. 1911. North Pacific **Ophiurans** in the collection of the U.S. Nat'l. Mus. Bull. U.S. Nat'l. Museum No. 75. pg. 1-302.
- Deichmann, E. 1930. The **Holothurians** of the Western Part of the Atlantic Coast. Bull. Mus. Corn. **Zool.** Vol. LXXI No. 3, pg. 43-226.
- Deichmann, E. 1938. **New Holothurians** of the Western Coast of North America and Some Remarks on the Genus Caudina. Proc. New Eng. **Zool. Club.** Vol. XVI. Pg. 103-115.
- D'yakonov, A. M. 1950. Sea Stars (asteroids) of the U. S. S. R. Seas. Acad. of Sci. of U. S. S. R. (Trans. from Russian. Israel **Prog. for Sci.**). Trans. 1968. pg. 1-183.

References (Cent'd.)

- D'yakonov, A.M.** 1954. **Ophiuroids** of the U.S.S.R. Seas. Acad. of **Sci. of USSR** (Trans. from Russian, Israel **Prog. for Sci.**). Trans. 1967. pg. 123.
- Edwards, **C.L.** 1908. The **Holothurians** of the North Pacific Coast of North America, collected by the Albatross in 1903. **Proc. U.S. Nat'l. Mus.** **33:49-68.**
- Fell, H.B.** 1960. Synoptic key to the Genera of **Ophiuroidea**. **Zool. Publ.** Victoria Un. Wellington. **26:3-34.**
- Fisher, **W.K.** 1911-1930. **Asteroidea** of the North Pacific and adjacent waters. Pt. 1 **Phanerozonia** and **Spinulosa**. 1911. Pg. 419. Pt. 2 **Forcipulata**. 1928. Pt. 3 **Forcipulata** (concluded) 1930. U.S. Nat'l. **Mus. Bull.** 76. P. 356.
- Ohshima, H. **1915.** Report on the **Holothurians** collected by the U.S. Fisheries Steamer "Albatross" in the Northwestern Pacific during the summer of **1906**. **Proc. U.S. Nat'l. Mus.** **48:213-291.**

CHORDATA - TUNICATA

Taxonomic Problems:

The **tunicates** represent a little known segment of the Alaskan fauna. Consequently, the **tunicates** were only occasionally identified. Those that are identified are correct to the level **reported**.

Species List:

Amaroncium glabrum

Molgula oregonia

Pelonaia corrugata

Sigillinaria sp.

Styela sp.

Synoncum sp.

References:

Berrill, N.J. 1950. The Tunicata, with an account of the British Species. Ray Society, pg. 1-354.

Millar, R.H. 1970. British **Ascidians**. Academic Press, New York, pg. 1-92.

Van Name, Willard G. 1945. The North and South American **Ascidians**. Bull. Amer. Mus. Nat. History. **84:1-476.**

CHORDATA - PISCES

Taxonomic Problems:

No taxonomic problem to the level reported.

Species List:

Clinocottus acuticeps

Clinocottus embryum

Gymnocanthus pistilligea

Liparis callyodon

Liparis sp.

Lumpenus sagitta

Oligocottus maculosus

Pholis sp.

Phytichthys chirus

Xiphister mucosus

References:

Hart, J.L. 1973. Pacific Fishes of Canada. Fisheries Research Board of Canada. Bull. 180, pg. 1-740.

Wilimovsky, N.J. 1958. Provisional keys to the Fishes of Alaska. Fisheries Res. Lab. U.S. Fish and Wildlife Service, Juneau; Alaska, pg. 113.

CHRYSTOPHYTA

Taxonomic Problems:

None.

Species List:

Licmophora sp.

References:

Cupp, **E.E.** 1943. Marine Plankton Diatoms of the West Coast of North America. Bull. Scripps Inst. **Oceanogr.** 5(1):1-238.

CYANOPHYTA

Taxonomic Problems:

The blue green algae are not authoritatively identified. The names submitted can only be considered provisional.

Species List:

Rivularia sp.

Microcoleus sp.

Lyngbya sp.

References:

Smith, **G.M.** 1950. The Freshwater Algae of the United States. McGraw-Hill Book Co., Inc., pg. 719.

CHLOROPHYTA

Taxonomic Problems:

The genera Spongomorpha and Cladophora in some instances were not separable in the material as submitted. These two genera are in addition not well understood in Alaska. **Formalin** preserved Ulva lactuca and U. fenestrata were difficult to separate and may be confused in the data.

Species List:

Cladophora sp.

Enteromorpha sp.

Enteromorpha clathrata

Lola sp./Rhizoclonium sp.

Monostroma cf. arcticum

Monostroma cf. zostericola

Prasiola sp.

Prasiola meridionalis

Rhizoclonium sp./Lola sp.

Rhizoclonium implexum

Rosenvingiella sp.

Rosenvingiella cf. polyrhiza

Schizogonium murale

Spongomorpha mertensii

Spongomorpha sp.

Spongomorpha cf. saxatilis

Spongomorpha spinescens

Species List (Cont'd.)

Ulothrix cf. flacca

Ulva fenestrata

Ulva lactuca

Urospora sp.

Urospora mirabilis

Urospora wormsjkoldii

References:

Abbott, **I.A.** and G. **Hollenberg**. 1976. The Marine Algae of California.
Stanford Univ. Press, pg. 827.

Scagel, R.F. 1966. Marine Algae of British Columbia and Northern
Washington, Part I. Chlorophyta. **Bull. Nat. Mus. Can.** 207:1-257.

Hock, C. van den. 1963. Revision of the European species of Cladophora.
Leiden, pg. 1-248.

PHAEOPHYTA

Taxonomic Problems:

The major **taxonomic** problem in this group **is** the genus Alaria. Material was submitted to **Widdowson** for identification. The resulting comments of **Widdowson** indicate that most of our identifications are probably correct but without large amounts of fertile material positive identification is impossible.

Species" List:

Alaria sp.

Alaria cf. angusta

Alaria cf. crisps

Alaria fistulosa

Alaria glandifolia

Alaria marginata

Alaria taeniata

Analipus filiformis

Analipus japonicus

Chordaria flagelliformis

Coilodesme polygnampta

Colpomenia bullosa

Cystoseira geminata

Desmarestia aculeata

Desmarestia viridis

Dictyosiphon sp.

Dictyosiphon sinicola

Dictyosiphonales

Ectocarpus sp.

Ectocarpus cf. parvus

Elachistea fucicola

cf. Feldmannia

Fucus Sp.

Fucus distichus

Fucus spiralis

Hedophyllum sessile

Laminaria sp.

Laminaria cf. ephemera

Laminaria groenlandica

Laminaria longipes

Laminaria saccharina

cf. Melanosiphon

Melanosiphon intestinalis

Petalonia fasciata

Species List (Cent'd.)

Phaeostrophion irregular

Pilayella littoralis

Ralfsia fungiformis

Ralfsiaceae

Saundersella simplex

Scytosiphon lomentaria

Soranthera ulvoidea

Sphacelaria racemosa

Thallasiophyllum clathrus

References:

Abbott, I.A. and G. Hollenberg. 1976. The Marine Algae of California. Standord Univ. Press, pg. 1-827.

Druehl, L.D. 1968. Taxonomy and distribution of NE Pacific species of Laminaria. Can. Jour. Bot. 46:539-47.

Setchell, W. and Gardner. 1925. The Marine Algae of the Pacific Coast of North America. Part 111. Melanophyceae. Univ. Calif. Publ. Bot. 13:1-13.

Widdowson, T. 1972. A taxonomic revision of the genus Alaria (Greville) Phaeophyta. Syesis 4:11-49.

Widdowson, T. 1973. The Marine Algae of B.C. and Northern Washington: Revised list and key. Part I. Phaeophyceae. Syesis 5:81-96.

Wynne, M. 1969. Life History and Systematic Studies of some Pacific N.A. Phaeophyceae. Univ. Calif. Publ. Bot. 50:1-88.

RHODOPHYTA

Taxonomic Problems:

Determinations of Porphyramoculosa and P. smithii should be changed to Porphyra sp. The material simply was not in good enough condition to make these determinations. Early determinations of Iridaea cornucopias are probably not correct. This species is regarded by many phycologists to be quite rare. M. Guiry is reviewing several Halosaccion/Rhodymenia - which have not been returned at this time. Antithamnion is poorly identified in this material.

Species List:

Acrochaetium sp.

Ahnfeltia plicata

Bangia fusco-purpurea

Bossiella sp.

Bossiella chiloensis

Bossiella cretacea

Bossiella plumosa

Callithamnion pikeanum

Callophyllis cristata

Callophyllis flabelluta

Ceramiceae

Ceramium pacificum

Chondrus cf. pinnulatus

Clathromorphum compactum

Clathromorphum reclinatum

Constantinea sp.

Constantinea subulifera

Corallina sp.

Corallina vancouverensis

Cryptonemiaceae

Cryptonemiales

Cryptosiphonia woodii

Delesseriaceae

Dilsea californica

Dumontia incrossata

Endocladia muricata

Species List (Cent'd.)

Farlowia mollis

Gigartina pacifica

Gigartina papillata (stellata) complex

Halosaccion sp.

Halosaccion glandiforme

Hypophyllum cf. dentatum

Iridaea sp.

Iridaea cordata

Iridaea cornucopia

Iridaea heterocordata

Lithothamnaceae

Melobesioideae

Microcladia borealis

cf. Neopolyporolithon

Neoptilota Sp.

Neoptilota aspleniodes

Nienburgia Sp.

Odonthalia floccosa

Odonthalia kamtschatica

Odonthalia washi ngtoni ensi s

Palmaria sp.

Palmaria palmata

Petrocelis sp.

Petrocelis fransci cana

cf. Peyssonellia sp.

Phycodrys riggii

Pleonosporium sp.

Polysiphonia cf. broderi

Polysiphonia hendryi

Polysiphonia pacifica

Porphyra sp.

Porphyra perforata

Pterosiphonia bipinnata

Pterosiphonia bipinnata f. robusta

Ptilota sp.

Ptilota filicina

Rhodomela larix

Rhodomelaceae

Rhodymenia sp.

Rhodymenia palmata f. sobolifera

Rhodymeniaceae

Tokitodendron bullata

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FINAL REPORT

BASELINE STUDIES OF THE **DEMERSAL** RESOURCES OF THE
EASTERN AND WESTERN GULF OF ALASKA SHELF AND SLOPE:
A HISTORICAL REVIEW

Research Unit 174

Principal Investigators:

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NOTE : We are sorry that the following errata sheets were not received in time to be included **in OCSEAP's** Final Reports, Vol. 2 (June 1978).

November 15, 1978 1/5

Demersal Fish and Shellfish Resources of the Gulf of Alaska from
Cape Spencer to Unimak Pass, 1948-1976

Volume 3 --Errata

Page 701, Paragraph 2

- 1. 2 Change 1,922 to 1,871
- 1. 3 Change 24% to 25%
- 1. 3 Change 57% to 59%
- 1. 4 Change 19% to 16%
- 1. 5 Change 64% to 67%
- 1. 6 Change 24% to 25%
- 1. 7 Change 16% to 17%

Page 701, Paragraph 3

- 1. 1 Change 10.9 to 10.6
- 1. 5 Change while to and
- 1. 5 Change 28.3 to 28.6
- 1. 6 Change Prince William to Sanak

Page 701, Paragraph 4

- 1. 1 Change 86% to 85%
- 1. 3 Change 86% to 84%
- 1. 6 Change 49% to 51%
- 1. 6 Change 33% to 32%

Page 706, Table XI-103

<u>REGION</u>	<u>DEPTH ZONE</u>	<u>CHANGE</u>
Fairweather	201-400	4.7 to 5.5
	0-400	4.6 to 4.7
Yakutat	201-400	U.*7 to 13.7
	0-400	7.7 to 7.9

Volume 3 -- Errata

Page 206, **Table** XI-103

<u>REGION</u>	<u>DEPTH ZONE</u>	<u>CHANGE</u>
Prince William	0-100	29.2 to 39.2
	101-200	34.7 to 46.5
	201-400	73.5 to 21.6
		28.3 to 8.3
		20.6 to 7.1
		36.1 to 14.2
	0-MO	203.6 to 151.7
Kenai		10.5 to 7.8
		10.6 to 8.1
	201-400	6.7 to 7.9
Kodiak	0-400	9.5 to 9.7
	201-400	24.3 to 26.5
	0-400	23.8 to 24.5
Shelikof	202-400	10.6 to 12.4
	0-400	3.4 to 3.5
Chirikof	201-400	14.3 to 16.7
	0-400	16.2 to 16.7
Sanak	201-400	7.1 to 8.3
	0-400	24.3 to 24.9
Total	0-100	24.2 to 24.8
	101-200	57.2 to 58.8
	201-400	358.2 to 306.3
		8.7 to 7.4
		18.7 to 16.4
	0-400	1,922.4 to 1,870.5
		10.9 to 10.6

Volume 3 -- Errata

Page 710, Paragraph 1

1. 6 Change 23% to 27%

Page 710, Paragraph 2

1. 1 Change 641 to 589
1. 2 Change 38% to 41%
1. 2 Change 32% to 26%
1. 2 Change 30% to 33%
1. 4 Change 57% to 50%

Page 710, Paragraph 3

1. 5 Change 14% to 16%

Page 711, Table XI-104

<u>SPECIES</u>	<u>DEPTH ZONE</u>	<u>CHANGE</u>
Roundfish	201-400	22.8 to 26.7
	0-boo	49.2 to 50.6
Flatfish	0-3.00	30.2 to 32.9
	101-200	37.7 to 41.0
	201-400	205.7 to 153.8
		5.0 to 3.7
		57.5 to 50.3
		32.1 to 26.1
Invertebrates	0-400	640.7 to 588.8
		3.6 to 3.3
		33.3 to 31.5
	201-400	13.8 to 16.2
	0-400	14.5 to 14.9
Rockfish	201-400	4.1 to 4.8
	0-400	1.5 to 1.6

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Volume 3 -- Errata

Page 711, Table XI-104

<u>SPECIES</u>	<u>DEPTH</u>	<u>ZONE</u>	<u>CHANGE</u>
Elasmobranchs	201-400		1.8 to 2.1
Total	0-100		24.2 to 24.8
	101-200		57.2 to 58.0
	201-400		357.6 to 305.7
			8.8 to 7.4
	0-400		18.6 to 16.4
	0-100		1922.8 to 1870.
			1009 to 10.6

Page 717, Table XI-106

<u>REGION</u>	<u>COLUMN</u>	<u>CHANGE</u>
Fairweather	4	6.2 to 6.8
Yakutat	4	13.1 to 14.3
Prince William	3	57,637.7 to 5,763.8
	3	89,048.3 to 37,174.4
	4	15.4 to 36.8
	4	19.9 to 47.7
	4	65.7 to 15.5
	4	13.9 to 6.3
Kenai	4	11.5 to 12.5
Kodiak	4	23.0 to 25.1
Shelikof	4	3.7 to 4.0
Chirikof	4	9.0 to 9.8
Sanak	4	19.4 to 22*2
Total	3	205,687.2 to 153,813.3
	3	640,677.4 to 588,803.5
	4	30.2 to 32.9

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Volume 3 --'Errata

Page 717, Table XI-106

<u>REGION</u>	<u>COLUMN</u>	<u>CHANGE</u>
Total	4	37.7 to 41.0
	4 ₂	32.1 to 26.1

Research Unit 174

Demersal Fish and Shellfish Resources
of the
Gulf of Alaska
from
Cape Spencer to Unimak Pass
1948 - 1976

A Historical Review

by
Lael L. Ronholt, Herbert H. Shippen,
and Eric S. Brown

August 1978

Volume 4

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DECADE COMPARISON BY SPECIES GROUP AND SPECIES

Species Groups	
Elasmobranchs	0*
Flatfish	0
Roundfish	0
Rockfish	0
Invertebrates	0

Species	
Skates	
Turbot	
Halibut	
Flathead sole	
Dover sole	
Resole	
Rock sole	
Sablefish	*
Cottids	
Pacific cod	
Walleye pollock	**
Pacific ocean perch	
Tanner crab	0*
King crab	0*

DISTRIBUTION OF BIOMASS BY DEPTH ZONE IN 1960 AND 1970.

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DECADE COMPARISON

INTRODUCTION

To examine long-term trends in the relative magnitude of fisheries resources within the Survey Area, a comparison was made between the catch per unit of effort (**kg/hr**) for the "1960" (actually 1961) survey by the **IPHC** and the **BCF** and the "1970" (actually 1973-1976) surveys by the **NMFS**.

Mean **CPUEs** (geometric) were calculated for each survey period, for each species or group, and for each region-depth zone. Where the various region-depth zones were combined, each mean CPUE was weighted in proportion to that part of the total area it represented.

Standard deviations were calculated for each region and depth zone, and a 2-standard deviation factor was used as a divisor and multiplier, respectively, to determine a confidence interval for the mean CPUE. If the mean CPUE index for either survey period fell within the 2-standard deviation confidence interval around the mean for the other period, no statistically-significant change in CPUE is presumed to have occurred. Where the geometric mean CPUE for the 1960's fell outside the 2-standard deviation confidence interval for the 1970's, and vice versa, a statistically-significant change is presumed to be evident.

Because of the relatively broad confidence intervals associated with the mean CPUE indices, few statistically-significant changes from the 1960's to the 1970's can be identified. Comparison between the mean **CPUEs** of the two periods, however, suggests that in many cases a large change occurred although statistical significance cannot be asserted.

To describe the nature of the changes that have occurred from 1960 until 1970 in the respective indices of density, the 1970 CPUE was divided by the 1960 CPUE and the resulting ratio coded and described as follows:

<u>1970 ÷ 1960 CPUE</u>	<u>CODE</u>	<u>DESCRIPTION</u>
0.51 to 2.00	0	No marked change
0.26 to 0.50		Moderate decrease
0.13 to 0.25	--	Large decrease
Less than 0.13	---	Very large decrease
2.01 to 4.00	+	Moderate increase
4.01 to 8.00	*	Large increase
Greater than 8.00	+++	Very large increase

DECADE COMPARISON BY SPECIES AND GROUP (GULF OF ALASKA)

For the Study Area as a whole, there were few statistically significant changes from 1960 to 1970 as determined by the comparison of the mean CPUEs (geometric) and confidence intervals. Statistically-significant increases were indicated for the roundfish group, Dover sole, and walleye pollock, while a statistically-significant decrease was indicated for Pacific ocean perch. Moderate increases in the CPUE index between 1960 and 1970 were determined for the invertebrate species group and rex sole (Table XII-1).

Table XII-1.--Decade comparison by species and species group (all regions and depth zones combined).

Species or Group	"1960s"		"1970s"		Confidence Interval	CPUE Ratio
	Mean CPUE ^{1/}	Confidence Interval ^{2/}	Mean CPUE ^{1/}	Confidence Interval ^{2/}	Comparison ^{3/}	1970÷1960
Group						
Elasmobranchs	4.50	2.16- 9.36	5.39	2.62- 11.10	N.C.	1.20 (o)
Flatfish	82.99	42.13-163.49	147.25	90.90-238.55	N.C.	1.77 (o)
Roundfish	27.70	12.15- 63.16	94.49	47.25-188.98	C.	3.41 (+)
Rockfish	4.22	1.98- 8.99	2.65	1.47- 4.77	N.C.	0.63 (0)
Invertebrates	19.37	6.22- 60.43	47.60	21.83-103.77	N.C.	2.46 (+)
Species						
Skates	3.49	1.73- 7.05	5.24	2.54- 10.79	N.C.	1.50 (o)
Turbot	23.05	10.48- 50.71	44.85	23.12- 87.01	N.C.	1.95 (o)
Halibut	5.45	2.53- 11.72	4.69	2.19- 10.04	N.C.	0.86 (o)
Flathead sole	6.49	2.80- 15.06	7.96	2.97- 21.33	N.C.	1.23 (0)
Dover sole	1.36	0.94- 1.97	2.28	1.37- 3.78	C.	1.68 (o)
Rex sole	1.81	1.10- 2.99	4.26	1.72- 10.52	N.C.	2.35 (+)
Rock sole	2.74	1.41- 5.34	3.35	1.62- 6.93	N.C.	1.22 (o)
Sablefish	2.28	1.26- 4.13	1.69	1.02- 2.81	N.C.	0.74 (0)
Cottids	4.50	2.74- 7.38	4.37	2.13- 8.96	N.C.	0.97 (0)
Pacific cod	4.71	1.96- 11.30	8.78	3.77- 20.46	N.C.	1.87 (0)
Walleye pollock	2.86	1.44- 5.66	17.57	5.09- 60.62	C.	6.14 (i-t)
Pac. o. perch	3.57	1.66- 7.68	1.38	0.84- 2.28	C.	0.39 (-)
Tanner crab	5.66	1.79- 17.94	5.78	2.28- 14.68	N.C.	1.02 (o)
King crab	1.69	0.86- 3.31	2.22	1.14- 4.25	N.C.	1.31 (0)

^{1/} Weighted geometric mean catch per unit of effort (kg/hour).

^{2/} Mean CPUE \pm 2 standard deviations.

^{3/} C. = "Change" (both means outside the confidence limits); **N.C.** = "No Change" (one or both means within the confidence limits).

DECADE COMPARISON ~~BY~~ REGIONS OF THE GULF OF ALAS^a

The Survey Area was divided into 9 regions ~~of which~~ 7 provided sufficient information in both the 1960 and 1970 surveys to permit comparison. Comparisons are made for Fairweather, **Yakutat**, Prince William, **Kenai**, Kodiak, **Chirikof**, and **Sanak**. The regions for which no comparisons are made include **Shelikof** and **Shumagin** (Figure XII-1).

1. Fairweather Region

In the Fairweather Region there were no statistically-significant changes in CPUE for any of the species ~~groups~~; however, the CPUES for all groups except **elasmobranchs** declined from 1960 to 1970 with moderate decreases indicated for flatfish and invertebrates. For the 14 species compared, only Tanner crab indicated a statistically-significant decrease while no **statistically-significant** increases were indicated. The CPUE ratio showed a moderate increase for 1 species, skates, while moderate decreases were indicated for turbot, halibut, Pacific cod, and Pacific ocean perch, and large decreases for sablefish and Tanner crab (Table XII-2).

Charts showing the distribution of Tanner crab in 1961 (Figure XI-177) and in 1976 (Figure XI-477) in the Fairweather Region indicate that greater densities of this species occurred between Cape Spencer and **Yakutat** Bay during the earlier survey than in the later.

2. **Yakutat** Region

In the **Yakutat** Region there were no statistically-significant changes in either the species groups or **species**, although 3 groups (**elasmobranchs**, flatfish, and roundfish) and 5 species (skates, turbot, Dover sole, rex sole, and **pollock**) showed moderate increases, and 1 species, Pacific ocean perch, showed a moderate decrease (Table XII-3).

3. Prince William Region

For the Prince William Region statistically-significant increases were shown in the roundfish group and the invertebrate group from 1960 to 1970, and a moderate increase was suggested for the flatfish group. Much of the **roundfish** increase was probably because of an increase in walleye **pollock**; no other species increased significantly. Moderate increases in the CPUE index did occur for turbot, flathead sole, Dover sole, rex sole, **cottids**, and Pacific cod, and a very large increase occurred for Tanner crab. The only marked decrease in the CPUE index from 1960 to 1970 was for Pacific, ocean perch (Table XII-4). The increase in the density of walleye **pollock** from 1961 (Figure XI-217) to 1975 (Figure XI-432) as reflected by CPUE appeared to be general throughout the entire Prince William Region. The 18-fold increase in the mean CPUE for **pollock**, together with lesser increases in the densities of Pacific cod, cottids, and sablefish, accounted for the large increase in the CPUE for roundfish. The more than 20-fold increase in the CPUE for invertebrates from 1960 (Figure XI-136) to 1970 (Figure XI-411) occurred principally among the Tanner crab in a broad arc from Kayak Island to Cape **Cleare** at the southwest end of Montague Island.

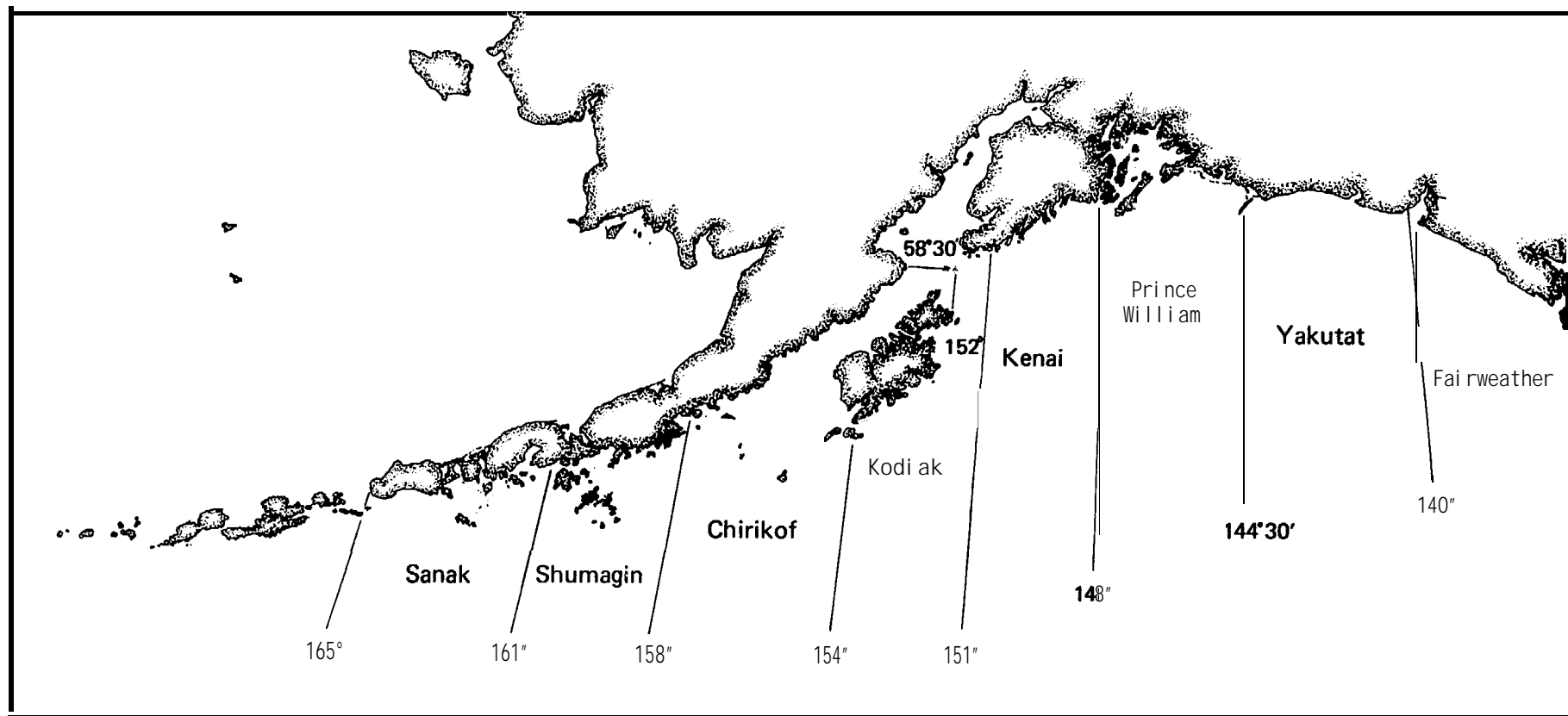


Figure XII-1.--Regions of the northern Gulf of Alaska Survey Area.

NOTE : Draw a line across the top of the Chirikof Region at $57^{\circ}00'N$ from the south end of Kodiak I. to the Alaska Peninsula. The area to the north of this line between Kodiak I. and the Alaska Peninsula should be labeled SHELIKOF.

Table XII-2. --Decade comparison by species and species groups for the **Fairweather** Region (depth zones combined).

Species or Groups	"1960s"		"1970s"		Confidence Interval Comparison@/	CPUE Ratio 1970÷1960
	Mean CPUE ^{1/}	Confidence Interval ^{2/}	Mean CPUE ^{1/}	Confidence Interval ^{2/}		
<u>Group</u>						
Elasmobranchs	11.99	1.16- 124.46	14.02	1.80-180.94	N.C.	1.17 (o)
Flatfish	191.01	20.54-1776.39	83.02	12.05-572.15	N.C.	0.43 (-)
Roundfish	16.16	1.26- 207.01	14.80	2.76- 79.48	N.C.	0.92 (0)
Rockfish	4.93	0.59- 41.07	2.86	0.38- 21.34	N.C.	0.58 (0)
Invertebrates	73.47	6.22- 868.42	36.88	4.43-307.21	N.C.	0.50 (-)
<u>Species</u>						
Skates	6.67	0.56- 78.84	13.53	1.89- 97.01	N.C.	2.03 (+)
Turbot	94.26	6.33-1402.59	31.21	3.42-284.64	N.C.	0.33 (-)
Halibut	5.20	0.76- 36.19	2.47	0.39- 15.71	N.C.	0.48 (-)
Flathead sole	7.11	0.42- 119.31	5.55	0.30-101.90	N.C.	0.78 (0)
Dover sole	2.06	0.46- 9.15	1.58	0.99- 2.53	N.C.	0.77 (o)
Rex sole	2.87	0.43- 19.00°	4.84	0.54- 43.66	N.C.	1.69 (0)
Rock sole	1.39	0.37- 5.20	1.13	0.73- 1.75	N.C.	0.81 (0)
Sablefish	4.92	0.38- 63.03	1.09	0.71- 1.68	N.C.	0.22 (--)
Cottids	1.19	0.37- 3.80	1.30	0.56- 3.04	N.C.	1.09 (o)
Pacific cod	4.05	0.39- 42.48	1.97	0.34- 11.33	N.C.	0.49 (-) \
Walleye pollock	1.69	0.54- 5.29	2.28	0.42- 12.47	N.C.	1.35 (o)
Pac. o. perch	3.40	0.46- 25.36	1.20	0.31- 4.63	N.C.	0.35 (-)
Tanner crab	10.03	2.89- 34.80	1.68	0.29- 9.66	C.	0.17 (--)
King crab	1.09	0.43- 2.79	1.14	0.41- 3.14	N.C.	1.05 (0)

^{1/} Weighted geometric mean catch per unit of effort (kg/hour).

^{2/} Mean CPUE \pm 2 standard deviations.

^{3/} C. = "Change" (**both** means Outside the confidence limits); **N.C.** = "NO Change" (one or both means within the confidence limits).

Table XII-3. --Decade comparison by species and species group for the **Yakutat** Region (depth **zones** combined).

Species or Group	"1960s"		"1970s"		Confidence Interval	CPUE Ratio
	Mean CPUE ^{1/}	Confidence Interval ^{2/}	Mean CPUE ^{1/}	Confidence Interval ^{2/}	Comparison ^{3/}	1970÷1960
Group						
Elasmobranchs	9.06	0.98- 83.44	21.80	5.44- 87.42	N.C.	2.41 (+)
Flatfish	76.16	10.83-535.40	166.20	40.54-681.42	N.C.	2.18 (+)
Roundfish	17.69	1.98-158.15	45.83	7.89-266.27	N.C.	2.59 (+)
Rockfish	9.60	1.04- 88.42	8.74	1.77- 43.26	N.C.	0.91 (o)
Invertebrates	43.22	4.42-422.69	43.90	7.56-255.06	N.C.	1.02 (o)
Species						
Skates	6.45	1.13- 36.77	20.34	4.87- 85.02	N.C.	3.15 (+)
Turbot	30.05	3.54-255.45	74.59	15.22-365.49	N.C.	2.48 (+)
Halibut	4.51	0.78- 26.20	3.60	0.63- 20.70	N.C.	0.80 (o)
Flathead sole	5.02	0.56- 45.28	4.74	0.44- 51.19	N.C.	0.94 (o)
Dover sole	1.89	0.47- 7.52	3.81	0.31- 46.86	N.C.	2.02 (+)
Rex sole	2.81	0.56- 14.19	6.66	0.47- 94.24	N.C.	2.37 (+)
Rock sole	1.14	0.59- 2.19	1.14	0.70- 1.85	N.C.	1.00 (o)
Sablefish	4.16	0.61- 28.37	2.85	0.32- 25.48	N.C.	0.69 (o)
Cottids	1.06	0.61- 1.67	1.60	0.37- 6.90	N.C.	1.00 (o)
Pacific cod	4.46	0.63- 31.35	4.83	0.70- 33.28	N.C.	1.08 (o)
Walleye pollock	4.05	0.53- 30.82	8.74	1.06- 72.11	N.C.	2.16 (+)
Pac. o. perch	6.34	0.59- 68.47	2.02	0.31- 13.11	N.C.	0.32 (-)
Tanner crab	3.34	0.58- 19.21	2.80	0.53- 14.73	N.C.	0.84 (o)
King crab	1.03	0.47- 2.25	--	--	--	--

^{1/} Weighted geometric mean catch per unit of effort (kg/hour).

^{2/} Mean CPUE ± standard deviations.

^{3/} C. = "Change" (both means outside the confidence limits); N.C. = "No Change" (one or both means within the confidence limits).

Table XII-4.--Decade comparison by species and species group for the Prince William Region (depth zones combined).

Species or Group	"1960s"		"1970s"		Confidence Interval Comparison/	CPUE Ratio 1970÷1960
	Mean CPUE ^{1/}	Confidence Interval ^{2/}	Mean CPUE ^{1/}	Confidence Interval ^{2/}		
Group						
Elasmobranchs	5.20	0.73- 37.28	7.94	0.95- 66.14	N.C.	1.53 (o)
Flatfish	32.12	8.09-127.52	107.09	25.38-451.92	N.C.	3.33 (+)
Roundfish	6.66	0.93- 47.75	100.65	24.55-412.67	C.	15.11 (+++)
Rockfish	3.99	0.61- 26.13	2.34	0.38- 14.30	N.C.	0.59 (o)
Invertebrates	5.30	1.02- 27.61	119.14	30.24-469.41	C.	22.48 (+++)
Species						
Skates	3.97	0.50- 31.76	7.61	0.90- 64.69	N.C.	1.92 (o)
Turbot	11.89	2.57- 54.93	41.59	13.86-124.77	N.C.	3.50 (+)
Halibut	3.37	0.72- 15.87	6.50	1.05- 40.11	N.C.	1.93 (o)
Flathead sole	4.32	1.37- 13.65	14.09	2.70- 73.41	N.C.	3.26 (+)
Dover sole	1.12	0.77- 1.62	2.59	0.68- 9.89	N.C.	2.31 (+)
Rex sole	1.48	0.69- 3.17	5.34	1.19- 23.92	N.C.	3.61 (+)
Rock sole	1.30	0.52- 3.22	1.17	0.50- 2.76	N.C.	0.90 (o)
Sablefish	1.58	0.80- 3.11	1.99	0.69- 5.75	N.C.	1.26 (o)
Cottids	1.03	0.84- 1.26	2.67	0.74- 9.69	N.C.	2.59 (+)
Pacific cod	2.09	0.36- 12.27	6.64	0.99- 44.42	N.C.	3.18 (+)
Walleye pollock	2.36	0.62- 8.92	41.66	4.48-387.44	C.	17.65 (+++)
Pac. o. perch	3.75	0.56- 25.09	1.29	0.39- 4.24	N.C.	0.34 (-)
Tanner crab	3.82	0.76- 19.10	45.36	3.76-547.04	N.C.	11.87 (+++)
King crab	--	--	--	--	--	--

^{1/} Weighted geometric mean catch per unit of effort (kg/hour).

^{2/} Mean CPUE \pm 2 standard deviations.

^{3/} C. = "Change" (both means outside the confidence limits); N.C. = "No Change" (one or both means within the confidence limits).

4. The Kenai Region

In the Kenai Region there was a statistically-significant decrease in the **elasmobranch** group's CPUE from 1960 to 1970, a large decrease in the rockfish group, and a moderate increase in the roundfish group. Among the 14 species, a statistically-significant decrease in CPUE occurred only for skates, a substantial part of the **elasmobranch** group. A moderate decrease took place in flathead **sole**, and very large decreases occurred in Pacific ocean perch and Tanner crab. The CPUE showed a very large increase from 1960 through 1970 for Dover sole, a large increase for rex sole, and a moderate increase for walleye pollock (Table XII-5).

The occurrence of moderate numbers of skates (**elasmobranchs**) in the Blying Sound area in 1961 (Figure XI-154) and their apparent lack in 1975 (Figure XI-425) accounts in large measure for the decline in the **elasmobranch** and skate CPUE indices over the decade. The apparent availability of **pollock** in the Kenai Region increased by a factor of more than 3 from 1961 (Figure XI-217) to 1975 (Figure XI-432).

5. The Kodiak Region

In the Kodiak Region no statistically-significant changes occurred in any of the species groups; however, 1 species, walleye **pollock**, showed a statistically-significant increase. A moderate increase also occurred in the **roundfish** and **flatfish** species groups. Among the species, moderate increases were found in Pacific cod, rock sole, Dover sole, and turbot, and a moderate decrease occurred for king crab (Table XII-6).

The increases in walleye **pollock** density from 1961 (Figure XI-218) to 1973 (Figure XI-433) largely occurred on Albatross Bank, **Portlock** Bank, and in the basin north of **Portlock** Bank.

6. The Chirikof Region

For the Chirikof Region, no statistically-significant changes were found in any of the species groups, and only 1 species, walleye **pollock**, had a statistically-significant increase. A moderate increase in the CPUE was found for the roundfish group, and moderate decreases occurred for flatfish and rockfish. Among the 14 species considered, a moderate increase was shown in the CPUE for Pacific cod and moderate decreases for the cottids, Pacific ocean perch, and king crab (Table XII-7).

The increase in the density of walleye **pollock** from 1960 to 1970 was widespread throughout the **Chirikof** Region (Figure XI-218 and Figure XI-433).

7. The Sanak Region

For the species groups and individual species in the Sanak Region, statistically-significant increases in CPUE occurred for the **flatfish** group, turbot, and sablefish, and no significant decreases were indicated. Large increases were noted for the roundfish and invertebrate groups, as well as for the king crab. Rex sole, rock sole, **sablefish**, and Pacific cod showed moderate increases and walleye **pollock** a very large increase. A moderate decrease was indicated for the **cottids** (Table XII-8).

Table XII-5. --Decade comparison by species and species group for the Kenai Region
(depth zones combined).

Species or Group	"1960s"		"1970s"		Confidence Interval Comparison ^{3/}	CPUE Ratio 1970÷1960
	Mean CPUE ^{1/}	Confident ^e Interval ^{2/}	Mean CPUE ^{1/}	Confidence Interval ^{2/}		
Group						
Elasmobranchs	19.91	2.75- 144.15	1.73	0.61- 4.90	c.	0.09 (---)
Flatfish	118.21	14.93- 936.22	103.96	11.07-976.18	N.C.	0.88 (o)
Roundfish	55.82	2.72-1143.75	112.43	18.05-700.44	N.C.	2.01 (+)
Rockfish	21.12	1.22- 365.16	4.40	0.51- 31.71	N.C.	0.21 (---)
Invertebrates	26.67	3.33- 213.36	14.66	1.09-197.32	N.C.	0.55 (o)
Species						
Skates	16.03	1.92- 133.53	1.73	0.61- 4.90	c.	0.11 (---)
Turbot	71.34	11.22- 453.72	50.26	5.46-462.89	N.C.	0.70 (o)
Halibut	2.40	0.32- 17.74	2.59	0.26- 25.23	N.C.	1.08 (o)
Flathead sole	36.32	4.06- 324.70	11.91	0.54-261.78	N.C.	0.33 (-)
Dover sole	1.03	0.89- 1.19	9.33	0.69-125.58	N.C.	9.06 (+++)
Rex sole	1.04	0.89- 1.22	7.03	0.90- 54.62	N.C.	6.76 (i-t-)
Rock sole	--	--	--	--	--	--
Sablefish	4.07	1.29- 12.86	3.16	0.47- 21.14	N.C.	0.78 (o)
Cottids	1.51	0.44- 5.22	2.29	0.44- 11.93	N.C.	1.52 (o)
Pacific cod	11.19	0.50- 248.42	18.54	3.10-111.05	N.C.	1.65 (o)
Walleye						
pollock	14.56	0.73- 289.60	50.86	3.45-749.17	N.C.	3.49 (+)
Pac. o. perch	19.22	0.93- 397.85	1.79	0.33- 9*70	N.C.	0.09 (---)
Tanner crab	24.96	1.22- 511.43	1.54	0.28- 8.59	N.C.	0.06 (---)
King crab	--	--	1.47	0.20- 10.97	--	--

^{1/} Weighted geometric mean catch per unit of effort (kg/hour).

^{2/} Mean CPUE \pm 2 standard deviations.

^{3/} c. = "Change" (both means outside the confidence limits); N.C. = "No Change" (one or both means within the confidence limits).

Table XII-6. --Decade comparison by species and species group for the Kodiak Region (depth zones combined).

Species or Group	"1960s"		"1970s"		Confidence Interval Comparison ^{3/}	CPUE Ratio 1970÷1960
	Mean CPUE ^{1/}	Confidence Interval ^{2/}	Mean CPUE ^{1/}	Confidence Interval ^{2/}		
Group						
Elasmobranchs	1.52	0.47- 4.89	1.11	0.65- 1.89	N.C.	0.73 (o)
Flatfish	134.76	36.72- 494.57	363.40	158.69-832.19	N.C.	2.70 (+)
Roundfish	76.40	22.54- 259.00	233.18	20.95-2595.29	N.C.	3.05 (+)
Rockfish	2.46	0.42- 14.44	1.53	0.76- 3.07	N.C.	0.62 (o)
Invertebrates	45.75	1.85-1133.69	74.94	7.66- 732.91	N.C.	1.64 (o)
Species						
Skates	1.48	0.46- 4.72	1.11	0.65- 1.89	N.C.	0.68 (o)
Turbot	13.42	1.93- 93.40	33* 12	5.21- 210.64	N.C.	2.47 (+)
Halibut	12.26	1.09- 137.93	13.10	2.62 - 65.50	N.C.	1.07 (o)
Flathead sole	5.53	0.76- 40.04	8.79	0.69- 111.46	N.C.	1.59 (o)
Dover sole	1.01	0.90- 1.13	2.21	0.58- 8.35	N.C.	2.19 (+)
Rex sole	1.34	0.54- 3.32	1.70	0.35- 8.18	N.C.	1.27 (o)
Rock sole	16.94	1.65- 174.14	55.48	0.94-3281.64	N.C.	3.28 (+)
Sablefish	1.20	0.67- 2.16	1.40	0.60- 3.28	N.C.	1.17 (o)
Cottids	39.65	9.40- 167.32	39.96	6.28- 254.15	N.C.	1.01 (o)
Pacific cod	5.97	0.73- 48.77	23.06	1.01- 527.38	N.C.	3.86 (+)
Walleye pollock	1.60	0.24- 10.48	25.77	0.47-1421.22	c.	17.36 (+++)
Pac. o. perch	2.26	0.39- 13.13	1.35	0.67- 2.69	N.C.	0.60 (o)
Tanner crab	13.72	0.97- 194.14	11.86	1.41- 99.86	N.C.	0.86 (o)
King crab	13.52	0.51- 359.36	6.62	0.40- 108.83	N.C.	0.49 (-)

^{1/} Weighted geometric mean catch per unit of effort (kg/hour).

^{2/} Mean CPUE ± 2 standard deviations.

^{3/} C. = "Change" (both means outside the confidence limits); **N.C.** = "No Change" (one or both means within the confidence limits).

le xII-7. --Decade comparison by species and species group for the **Chirikof** Region
(depth zones combined).

Species or Group	"1960s"		"1970s"		Confidence Interval Comparison ^{3/}	CPUE Rat io 1970÷1960
	Mean CPUE ^{1/}	Confidence Interval ^{2/}	Mean CPUE ^{1/}	Con fidence Interval ^{2/}		
<u>up</u>						
lasmobranchs	2.49	0.96- 6.45	1.46	0.61- 3.49	N.C.	0.59 (o)
latfish	158.14	57.51-434.89	68.60	16.26-289.49	N.C.	0.43 (-)
oundfish	59.47	19.00-186.14	125.10	33.72-464.12	N.C.	2.10 (+)
ockfish	4.66	0.70- 31.18	2.23	0.64- 7.72	N.C.	0.48 (-)
nvertebrates	19.48	1.70-223.44	20.28	3.42-120.26	N.C.	1.04 (o)
<u>ties</u>						
kates	2.42	0.92- 6.39	1.46	0.61- 3.49	N.C.	0.60 (0)
urbo t	28.20	8.25- 96.44	22.23	5.64- 87.59	N.C.	0.79 (o)
alibut	10.05	1.91- 52.86	5.32	1.20- 23.62	N.C.	0.53 (o)
lathead sole	7.90	2.03- 15.80	10.65	1.89- 60.07	N.C.	1.35 (o)
over sole	1.53	0.71- 3.27	1.79	0.71- 4.49	N.C.	1.17 (o)
ex sole	2.67	0.67- 10.71	2.48	0.71- 8.66	N.C.	0.93 (o)
ock sole	5.01	2.98- 8.42	2.78	0.77- 10.01	N.C.	0.55 (o)
ablefish	2.27	0.92- 5.58	1.58	0.75- 2.50	N.C.	0.70 (o)
ottids	20.11	4.62- 87.48	5.61	1.38- 22.78	N.C.	0.28 (-)
acific cod	3.77	1.06- 13.42	8.08	1.50- 43.39	N.C.	2.14 (+)
alleye pollock	3.43	0.83- 14.20	29.22	3.92-217.98	C.	8.52 (+++)
ac. o. perch	4.42	0.67- 28.95	1.40	0.54- 3.65	N.C.	0.32 (-)
anner crab	4.06	0.03-493.33	5.16	1.03- 25.80	N.C.	1.27 (0)
ing crab	8.07	0.84- 77.31	2.27	0.39- 13.32	N.C.	0.28 (-)

Weighted geometric mean catch per unit of effort (kg/hour).

Mean CPUE \pm 2 standard deviations.

C. = "Change" (both means outside the confidence limits); **N.C.** = "No Change" (one or both means within the confidence limits).

Table XII-8 ---Decade comparison by species and species group for the Sanak Region
(depth zones combined).

Species or Group	"1960s"		"1970s"		Confidence Interval Comparison ^{3/}	CPUE Ratio 1970÷1960
	Mean CPUE ^{1/}	Confidence Interval ^{2/}	Mean CPUE ^{1/}	Confidence Interval ^{2/}		
Group						
Elasmobranchs	1.31	0.56- 3.04	2.26	0.42- 12.14	N.C.	1.73 (o)
Flatfish	69.42	20.72-232.56	282.99	106.39- 752.75	c.	4.08 (++)
Roundfish	82.45	18.20-373.50	361.30	66.05-1976.31	N.C.	4.38 (++)
Rockfish	1.49	0.52- 4.26	1.11	1.09- 1.13	N.C.	0.74 (o)
Invertebrates	8.70	0.26-288.14	48.07	6.57- 351.87	N.C.	5.53 (++)
Species						
Skates	1.28	0.56- 2.93	2.26	0.42- 12.14	N.C.	1.77 (o)
Turbot	9.83	2.11- 45.81	53.11	12.21- 231.03	c.	5.40 (++)
Halibut	7.87	1.14- 54.22	5.90	0.90- 38.65	N.C.	0.75 (0)
Flathead sole	6.22	0.89- 43.29	7.67	0.67- 87.97	N.C.	1.23 (0)
Dover sole	1.03	0.82- 1.29	1.30	0.46- 3.68	N.C.	1.26 (0)
Rex sole	1.24	0.66- 2.33	3.04	0.31- 29.73	N.C.	2.45 (+)
Rock sole	10.21	1.04- 99.85	25.80	1.90- 350.88	N.C.	2.53 (+)
Sablefish	1.15	0.63- 2.12	2.81	1.98- 4.19	c.	2.44 (+)
Cottids	48.68	9.17-258.49	19.19	1.94- 189.41	N.C.	0.39 (-)
Pacific cod	8.08	0.87- 75.14	29.95	3.25- 275.84	N.C.	3.71 (+)
Walleye pollock	2.47	0.52- 11.76	33.26	0.59-1890.17	N.C.	13.47 (+++)
Pac. o. perch	1.49	0.53- 4.22	1.10	1.09- 1.11	N.C.	0.74 (o)
Tanner crab	4.74	0.21-108.40	5.46	0.40- 75.02	N.C.	1.15 (o)
King crab	1.99	0.18- 22.39	9.98	0.94- 105.69	N.C.	5.02 (++)

^{1/} Weighted geometric mean catch per unit of effort (kg/hour).

^{2/} Mean CPUE \pm 2 standard deviations.

^{3/} C. = "Change" (both means outside the confidence limits); N.C. = "No Change" (one or both means within the confidence limits).

The increase in the CPUE for the roundfish group from 1960 to 1970 stems largely from the increase in walleye **pollock** (Figure XI-218 and Figure XI-433).

DECADE COMPARISON BY DEPTH ZONE

On the **inner** shelf, 0-100 m, a comparison of geometric mean **CPUEs** for the 5 species groups indicates that all increased from the 1960's, and for the species, all but 2 also increased. On the outer shelf, 101-200 m, **CPUEs** for 4 of the species groups increased from 1960 to 1970; among the 14 species considered, **CPUES** for 8 increased and those for 6 decreased. With the species groups in the upper **slope** zone, 2 increased and 3 declined; there were increases in **CPUES** for 7 species, decreases in 6, and no change in 1.

1. The 0-100 m Depth Zone

For the 0-100 m depth zone, the inner shelf, there were **statistically-significant** increases in CPUE from 1960 to 1970 in the flatfish and roundfish groups and for turbot; there were no statistically-significant decreases in any group or species (Table XII-9).

In the ratios of the 1970 mean CPUE divided by that for 1960, there were moderate increases in Pacific cod and Tanner crab and large increases for invertebrates and walleye **pollock**.

2. The 101-200 m Depth Zone

For the 101-200 m depth zone, the outer shelf, there was a **statistically-significant** increase from 1960 to 1970 for only a **single** species, the walleye **pollock**, and there were no significant decreases. Moderate increases in the mean CPUE occurred with the roundfish and invertebrate species groups and with rex sole; a moderate decrease occurred with Pacific ocean perch (Table XII-10).

3. The 201-400 m Depth Zone

For the 201-400 m depth zone, the upper slope, there were no **statistically-significant** changes from 1960 to 1970 in species group **CPUES**, but a significant decrease did occur for Pacific ocean perch. A moderate increase was indicated in the roundfish group and large increases occurred in Dover sole and rex sole, while moderate decreases occurred in the **rockfish** group and Tanner crab (Table XII-11).

DECADE COMPARISON BY REGION-DEPTH ZONE

The changes in each region-depth zone from 1960 to 1970 based upon comparisons of mean **CPUES** (geometric) are listed below:

1. The Inner Shelf (0-100 m) Depth Zone (Table XII-12).

a. Fairweather Region

No marked changes: **Elasmobranchs**, **rockfish**, and invertebrates.

Moderate decreases: Halibut, rex sole, rock sole, walleye **pollock**, and Tanner crab.

Large decreases: Roundfish.

Very large decreases: Flatfish, turbot, flathead **sole**, and pacifi_c cod.

Table XII-9. --Decade comparison by species and species group for the 0-100 m depth zone (all regions combined).

Species or Group	"1960s"		"1970s"		Confidence Interval Comparison ^{3/}	CPUE Ratio 1970:1960
	Mean CPUE ^{1/}	Confidence Interval ^{2/}	Mean CPUE ^{1/}	Confidence Interval ^{2/}		
<u>Group</u>						
Elasmobranchs	2.19	0.93- 5.17	2.83	1.05- 7.64	N.C.	1.30 (o)
Flatfish	63.93	22.91-178.36	178.98	86.88-369.70	c.	2.80 (+)
Roundfish	29.73	7.56-116.84	126.12	41.22-385.93	c.	4.24 (++)
Rockfish	1.08	0.79- 1.47	1.09	0.69- 1.73	N.C.	1.00 (o)
Invertebrates	9.87	0.99- 98.01	57.18	13.76-237.30	N.C.	5.79 (++)
<u>Species</u>						
Skates	1.82	0.77- 4.30	2.76	1.03- 7.37	N.C.	1.52 (o)
Turbot	6.49	2.02- 20.83	29.70	11.08-79.6	c.	4.58 (++)
Halibut	9.13	2.13- 39.17	12.22	3.13-47.66	N.C.	1.34 (o)
Flathead sole	3.02	0.87- 10.51	5.04	1.20- 21.22	N.C.	1.67 (o)
Dover sole	1.03	0.87- 1.23	1.20	0.80- 1.80	N.C.	1.17 (o)
Rex sole	1.49	0.82- 2.70	2.28	0.91- 5.68	N.C.	1.53 (o)
Rock sole	8.72	1.96- 38.99	16.51	3.60- 75.62	N.C.	1.89 (o)
Sablefish	1.30	0.86- 1.98	1.13	0.80- 1.59	N.C.	0.87 (o)
Cottids	7.99	2.54- 25.09	14.33	3.62- 56.75	N.C.	1.79 (o)
Pacific cod	5.40	1.13- 25.92	12.31	1.91- 79.40	N.C.	2.28 (+)
Walleye pollock	1.71	0.66- 4.45	11.65	0.84-162.05	N.C.	6.83 (++)
Pac. o. perch	1.07	0.81- 1.41	1.00	0.99- 1.01	N.C.	0.93 (o)
Tanner crab	2.85	0.45- 17.84	7.93	1.42- 44.25	N.C.	2.78 (+)
King crab	2.51	0.40- 15.76	3.57	1.01- 12.60	N.C.	1.42 (o)

^{1/} Weighted geometric mean catch per unit of effort (kg/hour).

^{2/} Mean CPUE \pm 2 standard deviations.

^{3/} C. = "Change" (both means outside the confidence limits): N.C. = "No Change" (one or both means within the confidence limits).

Table XII-10. --Decade comparison by species and species group for the 101-200 m depth zone (**all** regions combined).

Species or Group	"1960s"		"1970s"		Confidence Interval	CPUE Ratio 1970÷1960
	Mean CPUE ^{1/}	Confidence Interval ^{2/}	Mean CPUE ^{1/}	Confidence Interval ^{2/}	Comparison ^{3/}	
Group						
Elasmobranchs	5.59	1.76- 17.77	6.82	2.05- 22.64	N.C.	1.22 (o)
Flatfish	92.10	31.33-270.77	116.50	48.54-279.60	N.C.	1.26 (0)
Roundfish	28.10	7.81-101.16	92.23	32.36-262.86	N.C.	3.28 (+)
Rockfish	4.90	1.18- 20.43	2.78	0.96- 8.03	N.C.	0.57 (o)
Invertebrates	20.46	4.18-100.25	45.47	15.68-131.86	N.C.	2.22 (+)
Species						
Skates	4.17	1.27- 13.72	6.59	1.98- 21.88	N.C.	1.58 (0)
Turbo t	38.10	10.61-136.78	47.77	16.76-136.14	N.C.	1.25 (0)
Halibut	6.31	2.07- 19.25	3.14	0.98- 10.05	N.C.	0.50 (-)
Flathead sole	9.35	2.40- 36.47	11.57	2.31- 57.85	N.C.	1.24 (0)
Dover sole	1.20	0.70- 2.06	1.98	0.83- 4.75	N.C.	1.65 (0)
Rex sole	1.67	0.76- 3.69	4.71	1.15- 19.22	N.C.	2.83 (+)
Rock sole	1.72	0.72- 4.09	1.68	0.61- 4.65	N.C.	0.97 (o)
Sablefish	2.23	0.78- 6.40	1.43	0.81- 2.53	N.C.	0.64 (0)
Cottids	4.34	2.38- 7.90	3.08	1.21- 7.85	N.C.	0.71 (0)
Pacific cod	5.42	1.41- 20.81	9.36	3.27- 26.77	N.C.	1.73 (o)
Walleye pollock	3.45	1.10- 10.87	30.58	5.80-161.16	c.	8.87 (+++)
Pac. o. perch	4.18	1.02- 17.18	1.55	0.69- 3.49	N.C.	0.37 (-)
Tanner crab	7.85	1.13- 54.48	5.48	1.37- 21.87	N.C.	0.70 (o)
King crab	1.33	0.78- 2.27	1.98	0.75- 5.25	N.C.	1.49 (0)

^{1/} Weighted geometric mean catch per unit of effort (kg/hour).

^{2/} Mean CPUE \pm 2 standard deviations.

^{3/} C. = "Change" (both means outside the confidence limits); N.C. = "No Change" (one or both means within the confidence limits).

Table XIII-11.--Decade comparison **by** species and species group for the 201-400 m depth zone (all regions combined).

Species or Group	"1960s"		"1970s"		Confidence Interval Comparison ^{3/}	CPUE Ratio 1970÷1960
	Mean CPUE ^{1/}	Confidence Interval ^{2/}	Mean CPUE ^{1/}	Confidence Interval ^{2/}		
<u>Group</u>						
Elasmobranchs	10.43	1.30- 83.88	9.89	3.13- 31.25	N.C.	0.95 (o)
Flatfish	131.34	39.92-432.11	211.28	37.80-1181.06	N.C.	1.61 (0)
Roundfish	22.46	6.38- 79.06	53.85	10.97- 264.40	N.C.	2.40 (+)
Rockfish	51.01	15.65-166.29	16.38	4.93- 54.38	N.C.	0.32 (-)
Invertebrates	52.18	13.66-198.93	36.92	5.20- 262.13	N.C.	0.71 (o)
<u>Species</u>						
Skates	9.06	2.46- 33.34	9.82	2.98- 32.41	N.C.	1.08 (0)
Turbot	67.69	17.77-257.90	89.23	21.50- 370.30	N.C.	1.32 (0)
Halibut	2.05	0.77- 5.43	1.65	0.69- 3.96	N.C.	0.80 (0)
Flathead sole	10.10	2.14- 47.57	6.07	1.19- 31.02	N.C.	0.60 (0)
Dover sole	3.77	0.77- 18.55	15.17	0.69- 333.28	N.C.	4.02 (++)
Rex sole	3.74	0.89- 15.63	15.46	0.77- 310.44	N.C.	4.14 (++)
Rock sole	1.04	0.84- 1.29	1.04	0.87- 1.24	N.C.	1.00 (o)
Sablefish	8.58	2.28-32.26	7.30	0.47- 112.42	N.C.	0.85 (0)
Cottids	1.43	0.92- 2.22	2.56	0.41- 16.00	N.C.	1.79 (0)
Pacific cod	2.18	0.97- 4.91	3.35	0.89- 12.63	N.C.	1.54 (o)
Walleye pollock	4.74	1.86- 12.09	6.53	1.50- 28.34	N.C.	1.38 (0)
Pac. o. perch	29.69	11.64- 75.71	1.90	0.30- 11.89	c.	0.06 (---)
Tanner crab	8.46	1.96- 36.55	3.90	1.05- 14.43	N.C.	0.46 (-)
King crab	1.52	0.83- 2.80	1.29	0.70- 2.37	N.C.	0.85 (0)

^{1/} Weighted geometric mean catch per unit of effort (kg/hour).

^{2/} Mean CPUE ± 2 standard deviations.

^{3/} C. = "Change" (both means outside the confidence limits); N.C. = "No Change" (one or both means within the confidence limits).

Table XIII-12--Ratio of the **1970+1960** geometric mean CPUE index (**kg/hr**) for the 0-100 m depth zone by region of the **Gulf** of Alaska.

Species or Group	REGION						
	Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak
<u>Group</u>							
Elasmobranchs	1.88	2.25	2.02	--	--	--	--
Flatfish	0.09	1.85	11.29	--	2.86	0.46	3.90
Roundfish	0.17	11.31	18.87	--	2.12	1.47	3.55
Rockfish	0.98	0.99	--	--	--	--	--
Invertebrates	1.83	2.48	87.05	--	4.99	0.52	3.18
<u>Species</u>							
Skates	3.13	3.37	2.64	--	--	--	--
Turbot	0.10	1.55	18.66	--	3.35	2.90	7.35
Halibut	0.38	3.06	3.64	--	2.26	0.21	0.88
Flathead sole	0.07	2.35	8.79	--	1.66	2.03	0.98
Dover sole	--	1.57	--	--	--	--	--
Rex sole	0.40	1.88	2.72	--	1.73	1.61	1.26
Rock sole	0.33	1.32	0.76	--	5.15	0.46	5.32
Sablefish	--	0.59	--	--	--	--	--
Cottids	--	0.82	--	--	1.22	0.50	0.96
Pacific cod	0.11	7.05	2.41	--	5.12	0.93	2.65
Walleye pollock	0.50	12.50	--	--	10.01	2.98	4.29
Pac. o. perch	--	0.99	--	--	--	--	--
Tanner crab	0.41	3.26	42.23	--	1.85	1.39	0.95
King crab	--	--	--	--	0.66	0.11	4.66

Moderate increases: Skates,
Large increases: None.
Very large increases: None.

b. **Yakutat** Region

No marked changes: Flatfish, **rockfish**, turbot, Dover sole, rex sole, rock sole, **sablefish**, **cottids**, and Pacific ocean perch.
Moderate decreases: None.
Large decreases: None.
Very large decreases: None.
Moderate increases: Elasmobranchs, invertebrates, skates, halibut, **flathead** sole, and Tanner crab,
Large increases: Pacific cod,
Very large increases: Roundfish and walleye **pollock**.

c, Prince William Region

No marked changes: Rock sole.
Moderate decreases: None.
Large decreases: None.
Very large decreases: None.
Moderate increases: **Elasmobranchs**, skates, halibut, rex sole, and Pacific cod.
Large increases: None.
Very large increases: **Flatfish**, roundfish, invertebrates, turbot, flathead sole, and Tanner crab,

d, Kenai Region

No comparative information in the 0-100 m depth zone.

e, Kodiak Region

No marked changes: Flathead sole, rex sole, cottids, Tanner crab, and king crab.
Moderate decreases: None.
Large decreases: None.
Very large decreases: None,
Moderate increases: Flatfish, roundfish, turbot, and halibut,
Large increases: Invertebrates, rock sole, and Pacific **cod**,
Very large increases: Walleye **pollock**.

f. Chirikof Region

No marked changes: Roundfish, invertebrates, rex sole, Pacific cod, and Tanner crab
Moderate decreases: Flatfish, rock sole, and **cottids**.
Large decreases: Halibut.
Very large decreases: King crab,
Moderate increases: Turbot, **flathead** sole, and walleye **pollock**.
Large increases: None.
Very large increases: None,

g. Sanak Region

No **marked** changes: Halibut, flathead sole, rex sole, **cottids**, and Tanner crab.

Moderate decreases: None.

Large decreases: None.

Very large decreases: None.

Moderate increases: Flatfish, roundfish, invertebrates, and Pacific cod.

Large increases: Turbot, rock sole, walleye **pollock**, and king crab.

Very large increases: None.

2. The Outer Shelf (101-200 m) Depth Zone (Table XII-13)

a. Fairweather Region

No marked changes: **Elasmobranchs**, roundfish, rockfish, invertebrates, **flathead** sole, Dover sole, rock sole, **cottids**, Pacific cod, walleye **pollock**, and king crab.

Moderate decreases: **Flatfish**, turbot, halibut, sablefish, and Pacific ocean perch.

Large decreases: Tanner crab.

Moderate increases: Skates and rex sole.

Large increases: None.

Very large increases: None.

b. Yakutat Region

No marked changes: **Elasmobranchs**, roundfish, rockfish, invertebrates, halibut, flathead sole, Dover sole, rex sole, Pacific cod, walleye **pollock**, and Tanner crab.

Moderate decreases: **Sablefish** and Pacific ocean perch.

Large decreases: None.

Very large decreases: None.

Moderate increases: **Flatfish**, skates, and **turbot**.

Large increases: None.

Very large increases: None.

c. Prince William Region

No marked changes: **Elasmobranchs**, flatfish, skates, **turbot**, halibut, and sablefish.

Moderate decreases: Rockfish and Pacific ocean perch.

Large decreases: None.

Very large decreases: None.

Moderate increases: **Flathead** sole, Dover sole, rex sole, and **cottids**.

Large increases: Pacific cod and Tanner crab.

Very large increases: Roundfish, invertebrates, and walleye **pollock**.

d. Kenai Region

No marked changes: Flatfish, invertebrates, turbot, halibut, **sablefish**, **cottids**, and Pacific cod.

Moderate decreases: Rockfish and flathead sole.

Large decreases: Skates and Pacific ocean perch.

Very large decreases: **Elasmobranchs** and Tanner crab.

Moderate increases: Roundfish.

Large increases: None.

Very large increases: Dover sole, rex sole, and walleye **pollock**.

Table XII-13. --Ratio of the **1970+1960** geometric mean CPUE index (kg/hr) for the 101-200 m depth zone by region of the Gulf of Alaska.

Species or Group	REGION						
	Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak
<u>Group</u>							
Elasmobranchs	1.17	1.91	1.11	0.10	0.65	0.66	3.47
Flatfish	0.30	2.29	1.41	1.23	2.07	0.35	3.90
Roundfish	1.40	1.14	18.28	3.01	4.27	3.32	5.22
Rockfish	0.52	1.12	0.41	0.28	0.31	0.50	--
Invertebrates	0.51	1.21	9.30	0.79	0.37	1.30	9.14
<u>Species</u>							
Skates	2.09	2.57	1.40	0.13	0.65	0.60	3.61
Turbot	0.26	2.87	1.53	1.05	1.53	0.43	3.47
Halibut	0.43	0.51	0.57	0.91	0.38	0.12	0.63
Flathead sole	1.17	1.24	2.35	0.31	2.61	0.75	1.45
Dover sole	0.68	1.50	2.34	9.50	3.73	1.16	1.54
Rex sole	2.21	1.83	3.51	7.37	1.99	0.78	4.70
Rock sole	0.95	--	--	--	1.62	0.45	1.20
Sablefish	0.33	0.36	1.07	1.16	1.08	0.62	1.03
Cottids	0.93	--	2.03	1.54	0.43	0.14	0.15
Pacific cod	0.64	0.51	4.83	1.58	4.59	1.70	5.61
Walleye pollock	1.59	1.78	24.80	8.02	32.10	68.49	43.85
Pac. o. perch	0.47	0.34	0.29	0.15	0.36	0.30	--
Tanner crab	0.13	0.90	4.91	0.10	0.46	0.97	1.44
King crab	1.14	--	--	--	0.43	0.49	6.17

e. Kodiak Region

No marked changes: Elasmobranchs, skates, turbot, rex sole, rock sole, and sablefish.
Moderate decreases: Invertebrates, halibut, **cottids**, Tanner crab, king crab, **rockfish**, and Pacific ocean perch.
Large decreases: None.
Very **large decreases**: None.
Moderate increases: Flatfish, flathead sole, and Dover sole.
Large increases: Roundfish and Pacific cod.
Very large increases: Walleye **pollock**.

f. Chirikof Region

No marked changes: **Elasmobranchs**, invertebrates, skates, **flathead** sole, Dover sole, rex sole, sablefish, Pacific cod, and Tanner crab.
Moderate decreases: Flatfish, rockfish, turbot, rock sole, Pacific ocean perch, and king crab.
Large decreases: **Cottids**.
Very large decreases: Halibut.
Moderate increases: Roundfish.
Large increases: None.
Very large increases: Walleye **pollock**.

g. Sanak Region

No marked changes: Halibut, **flathead** sole, Dover sole, rock sole, sablefish, and Tanner crab.
Moderate decreases: None.
Large decreases: Cottids.
Very large decreases: None.
Moderate increases: **Elasmobranchs**, **flatfish**, skates, and turbot.
Large increases: Roundfish, rex sole, Pacific cod, and king crab.
Very large increases: Invertebrates and walleye **pollock**.

3. The Upper Slope (201-400 m) Depth Zone (Table XII-14)

a. Fairweather Region

No marked changes: **Elasmobranchs**, roundfish, rockfish, skates, flathead sole, Dover sole, and walleye **pollock**.
Moderate decreases: None.
Large decreases: None.
Very large decreases: Invertebrates and sablefish.
Moderate increases: Flatfish, rex sole, and cottids.
Large increases: *Turbot*.
Very large increase: None.

b. Yakutat Region

No marked changes: **Rockfish**, halibut, Pacific cod, and walleye **pollock**.
Moderate decreases: Invertebrates.
Large decreases: **Flathead** sole and Tanner crab.
Very large decreases: Pacific ocean perch.
Moderate ~~i_ncreases~~ **Flatfish**, roundfish, turbot, and sablefish.
Large increases: **Elasmobranchs**, skates, Dover sole, and rex sole.
Very **large increases**: None.

Table XII-14. --Ratio of 1970÷1960 geometric mean CPUE index (kg/hr) for the 201-400 m depth zone by region of the Gulf of Alaska.

Species or Group	REGION						
	Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak
<u>Group</u>							
Elasmobranchs	0.67	4.37	1.94	0.06	--	0.30	1.15
Flatfish	3.05	2.29	1.52	0.40	4.92	0.55	13.76
Roundfish	0.72	3.94	3.98	0.80	13.71	1.63	9.14
Rockfish	0.54	0.55	0.14	0.06	12.24	0.19	0.78
Invertebrates	0.10	0.31	7.80	0.24	0.11	1.66	--
<u>Species</u>							
Skates	1.02	4.60	2.14	0.07	--	0.31	1.15
Turbot	4.95	2.79	0.39	0.28	1.58	0.44	20.51
Halibut	--	.63	--	1.59	0.19	1.93	0.81
Flathead sole	1.68	0.23	0.51	0.37	0.15	1.99	--
Dover sole	1.18	4.82	6.08	--	--	1.32	4.75
Rex sole	2.16	5.09	9.46		--	0.65	7.73
Rock sole	--	--	--	--	1.61	0.92	--
Sablefish	0.06	3.03	1.32	0.30	--	0.50	2.12
Cottids	2.95	--	--	--	7.10	0.39	0.36
Pacific cod	--	1.00	1.74	1.84	0.22	7.65	2.13
Walleye pollock	1.88	0.67	1.51	0.52	--	1.47	35.22
Pac. o. perch	--	0.10	0.03	--	2.79	0.09	0.24
Tanner crab	--	0.21	5.35	0.05	0.05	1.69	--
King crab	--	--	--	--	0.08	0.37	--

c. Prince William Region

No marked changes: **Elasmobranchs**, **flatfish**, flathead sole, **sablefish**, Pacific cod, and walleye **pollock**.
Moderate decreases: Turbot.
Large decreases: **Rockfish**
Very large decreases: Pacific ocean perch.
Moderate increases: Roundfish and skates.
Large increases: Invertebrates, Dover sole, and Tanner crab.
Very large increases: Rex sole.

d. Kenai Region

No marked changes: Roundfish, halibut, Pacific cod, and **walleye pollock**.
Moderate decreases: **Flatfish**, turbot, flathead **sole**, and **sablefish**.
Large decreases: Invertebrates.
Very large decreases: Elasmobranchs, **rockfish**, skates, and Tanner crab.
Moderate increases: None.
Large increases: None.
Very large increases: None.

e. Kodiak Region

No marked changes: Turbot and rock sole.
Moderate decreases: None.
Large decreases: Halibut, **flathead** sole, and pacific cod.
Very large decreases: Invertebrates, and Tanner and king crab.
Moderate increases: Pacific ocean perch.
Large increases: Flatfish and **cottids**.
Very large increases: Roundfish and rockfish.

f* Chirikof Region

No marked changes: **Flatfish**, roundfish, invertebrates, halibut, flathead sole, Dover sole, rex sole, rock sole, walleye **pollock**, and Tanner crab.
Moderate decreases: **Elasmobranchs**, skates, turbot, sablefish, cottids, and king crab.
Large decreases: **Rockfish**.
Very large decreases: Pacific ocean perch.
Moderate increases: None.
Large increases: Pacific cod.
Very large increases: None.

g. Sanak Region

No marked changes: Elasmobranchs, rockfish, skates, and halibut.
Moderate decreases: Cottids.
Large decreases: Pacific ocean perch.
Very large decreases: None.
Moderate increases: Sablefish and Pacific cod.
Large increases: Dover sole and rex sole.
Very large increases: Flatfish, **roundfish**, turbot, and walleye **pollock**.

DECADE COMPARISON BY SPECIES GROUP AND SPECIES

1. Species Groups

a. Elasmobranchs (Table XII-15)

The overall CPUE for **elasmobranchs** showed no marked change from 1960 to 1970 within the Gulf of Alaska. Within the regions, a moderate increase in CPUE occurred in Yakutat and a very large (statistically-significant) decrease in Kenai. No marked changes occurred in any other region or depth zone. A large increase in the CPUE for **elasmobranchs** occurred in the Yakutat-upper slope. Very large decreases occurred in the Kenai-outer shelf and Kenai-upper slope. Thus, the Kenai region saw a large decline in **elasmobranchs** from 1960 to 1970.

b. Flatfish (Table XII-16)

No marked change occurred in the overall density of flatfish in the Gulf of Alaska from 1960 to 1970. Within the regions, there were moderate increases in Yakutat, Prince William, and Kodiak; a large (statistically-significant) increase in Sanak; and moderate decreases in Fairweather and Chirikof. A moderate (statistically-significant) increase occurred in the CPUE for flatfish within the inner shelf depth zone, but no marked changes were indicated in the other depth zones. Individual region-depth zones with large or very large increases in the flatfish group from 1960 to 1970 were the Prince William-inner shelf, Kodiak-upper slope, and the Sanak upper slope. The Fairweather-inner shelf had a very large decrease in the flatfish CPUE in the decade from 1960 to 1970.

c. Roundfish (Table XII-17)

The CPUE for the roundfish group within the Gulf of Alaska showed a moderate (statistically-significant) increase from 1960 to 1970. The CPUE increased moderately in the Yakutat, Kenai, Kodiak, and Chirikof Regions; a large increase occurred in Sanak; and a very large (statistically-significant) increase occurred in Prince William. Among the depth zones, a large (statistically-significant) increase occurred in the inner shelf and moderate increases occurred in the outer shelf and upper slope zones. No decreases were indicated in any region or depth zone. The individual region-depth zones with marked increases were the Kodiak-outer shelf and the **Sanak-outer** shelf with large increases, and the Yakutat-inner shelf, the Prince William-inner shelf, the Prince William-outer shelf, the Kodiak-upper slope, and the **Sanak-upper** slope with very large increases. A large decrease in CPUE occurred in the FairWeather-inner shelf. Thus, the roundfish group apparently increased throughout much of the Gulf of Alaska from 1960 to 1970 in all regions except the extreme eastern part of the Survey Area.

d. Rockfish (Table XII-18)

The rockfish was the only species group to show a decline in CPUE from 1960 to 1970 in the Gulf of Alaska as a whole (Table XII-1). Within the various regions of the Gulf of Alaska, the CPUE for rockfish did not show a marked

Table XII-15. --Ratio of 1970÷1960 geometric mean CPUE index (kg/hr)^{1/} for elasmobranchs.

Species or *ties Croup	Depth Zone (m)	REGION							Total
		Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak	
Elasmobranchs	0-100	0	+	+	<u>2/</u>	<u>2/</u>	<u>2/</u>	<u>2/</u>	0
	101-200	0	0	0	---	0	0	+	0
	201-400	0	*	0	---	<u>2/</u>		0	0
	Total	0	+	0	---4/	0	0	0	0

Table XII-16. --Ratio of 1970÷1960 geometric mean CPUE index (kg/hr)^{1/} for flatfish.

Species or Species Group	Depth Zone (m)	REGION							Total
		Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak	
Flatfish	0-100	---	0	+++	<u>2/</u>	+		+	<u>+3/</u>
	101-200		+	0	0	+		+	0
	201-400	+	+	0		i-t	0	+++	0
	Total		+	+	0	+		<u>++3/</u>	0

<u>1/</u> Code	<u>Ratio</u>	<u>Description</u>	<u>2/</u> Insufficient data.
0	0.51-2.00	No marked change, 1960-1970	
	0.26-0.50	Moderate decrease, 1960-1970	
--	0.13-0.25	Large decrease, 1960-1970	
---	Less than 0.13	Very large decrease, 1960-1970	
+	2.01-4.00	Moderate increase, 1960-1970	
++	4.01-8.00	Large increase, 1960-1970	
+++	Greater than 8.00	Very large increase, 1960-1970	
			<u>3/</u> Significant increase indicated by confidence interval.
			<u>4/</u> Significant decrease indicated by confidence interval.

Table XII-17. --Ratio of 1970÷1960 geometric mean CPUE index (kg/hr)^{1/} for roundfish.

Species or Species Group	Depth Zone (m)	REGION							Total
		Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak	
Roundfish	0-100	-.	+++	+++	<u>2/</u>	+	0	+	++ <u>3/</u>
	101-200	0	0	+++	+	*	+	-H-	+
	201-400	0	+	+	0	+++	0	+++	+
	Total	0	+	+++ <u>3/</u>	+	+	+"	-1-t	+ <u>3/</u>

Table XII-18. --Ratio of 1970÷1960 geometric mean CpUE index (kg/hr)^{1/} for rockfish.

Species or Species Group	Depth Zone (m)	REGION							Total
		Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak	
Rockfish	0-100	0	0	<u>2/</u>	<u>2/</u>	<u>2/</u>	<u>2/</u>	<u>2/</u>	0
	101-200	0	0			0		<u>2/</u>	0
	201-400	0	0	--	---	+++	--	0	
	Total	0	0	0	--	0		0	0

<u>1/</u> Code	<u>Ratio</u>	<u>Description</u>	<u>2/</u> Insufficient data.
0	0.51-2.00	No marked change, 1960-1970	
	0.26-0.50	Moderate decrease, 1960-1970	
--	0.13-0.25	Large decrease, 1960-1970	
---	Less than 0.13	Very large decrease, 1960-1970	
+	2.01-4.00	Moderate increase, 1960-1970	
-H-	4.01-8.00	Large increase, 1960-1970	
-H-1-	Greater than 8.00	Very large increase, 1960-1970	

3/ Significant increase indicated by confidence interval.

Table XII-19. --Ratio of 1970÷1960 geometric mean CPUE index (kg/hr)^{1/} for invertebrates.

Species or Species Group	Depth Zone (m)	REGION							Total
		Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak	
Invertebrates	0-100	0	+	+++	<u>2/</u>	++	0	i-	i-l-
	101-200	0	0	+++	0		0	+++	+
	201-400	---		*	--	- --	0	<u>2/</u>	0
	Total		0	+++ <u>3/</u>	0	0	0	i-l-	+

Table XII-20. --Ratio of 1970÷1960 geometric mean CPUE index (kg/hr)^{1/} for skates.

Species or Species Group	Depth Zone (m)	REGION							Total
		Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak	
Skates	0-100	+	+	+	<u>2/</u>	<u>2/</u>	<u>2/</u>	<u>2/</u>	0
	101-200	+	+	0	--	0	0	+	0
	201-400	0	*	+	---	<u>2/</u>		0	0
	Total	+	+	0	--- <u>3/</u>	cl	0	0	0

<u>1/</u>	<u>Code</u>	<u>Ratio</u>	<u>Description</u>	<u>2_/</u>	<u>Insufficient data.</u>
	0	0.50-2.00	No marked change, 1960-1970		
		0.26-0.50	Moderate decrease, 1960-1970		
	--	0.13-0.25	Large decrease, 1960-1970		
	---	Less than 0.13	Very large decrease, 1960-1970		
	+	2.01-4.00	Moderate increase, 1960-1970		
	*	4.01-8.00	Large increase, 1960-1970		
	+++	Greater than 8.00	Very large increase, 1960-1970		
				<u>3/</u>	Significant increase indicated by confidence interval.

Table XII-21. --Ratio of 1970<-1960 geometric mean CPUE index (kg/hr)^{1/} for turbot.

Species or Species Group	Depth Zone (m)	REGION							Total
		Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak	
Turbot	o-100	---	0	+++	2/	+	+	++	* 3/
	101-200		+	o	0	o		+	0
	201-400	i-t	+			0		+++	0
	Total		+	+	0	+	0	++3/	0

Table XII-22. --Ratio of 1970÷1960 geometric mean CPUE index (kg/hr)^{1/} for halibut.

Species or Species Group	Depth Zone (m)	REGION							Total
		Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak	
Halibut	o-100		+	+	2/	+	.-	0	0
	101-200		0	0	0		---	0	
	201-400	2/	0	2/	0	--	0	0	0
	Total		0	0	0	0	0	0	0

<u>1/ Code</u>	<u>Ratio</u>	<u>Description</u>	<u>2/ Insufficient data.</u>
o	0.51-2.00	No marked change, 1960-1970	
	0.26-0.50	Moderate decrease, 1960-1970	
--	0.13-0.25	Large decrease, 1960-1970	
---	Less than 0.13	Very large decrease, 1960-1970	
+	2.01-4.00	Moderate increase, 1960-1970	
++	4.01-8.00	Large increase, 1960-1970	
+++	Greater than 8.00	Very large increase, 1960-1970	
			<u>3/ Significant increase indicated by confidence interval.</u>

change except in **Chirikof** with a moderate decrease and **Kenai** with a large decrease. Among the depth zones, there were no marked changes in CPUE in the inner and outer shelf zones and a moderate decrease in the upper slope. Individual region-depth zones with large or very large increases in the **rockfish** included only the Kodiak-upper slope with a very large increase. Decreases in CPUE occurred in the Prince William-upper slope and **Chirikof**-upper slope which had large decreases, and a very large decrease occurred in the Kenai-upper slope. Thus, the more dramatic changes in CPUE for **rockfish** occurred during the decade from 1960 to 1970 in the upper slope depth zone with the Kodiak-upper slope showing sharp increases and adjacent regions showing decreases.

e. Invertebrates (Table XII-19)

A moderate increase occurred in the CPUE index for the invertebrate group from 1960 to 1970 in the Gulf of Alaska. Within the regions, no marked changes were found in the **Yakutat**, **Kenai**, Kodiak, and Chirikof Regions, while a moderate decrease occurred in Fairweather, a large increase in **Sanak**, and a very large (statistically-significant) increase in Prince William. Within the 3 depth zones of the Gulf of Alaska, there was no marked change in the upper slope, a moderate increase in the outer shelf, and a large increase in the inner shelf. Region-depth zones with large or very large changes included a large decrease in the Kenai-upper slope and very large decreases in the Fairweather-upper slope and the Kodiak-upper slope; a large increase in CPUE took place in the Kodiak-inner shelf and the Prince William-upper slope. Very large increases occurred in the 2 shelf zones of the Prince William Region and in the Sanak-outer shelf. Thus, the decade saw dramatic increases in the CPUE indices for invertebrates in the Prince William and Sanak Regions, and either little change or marked decreases occurred in much of the remainder of the Survey Area.

2. Species

a. Skates (Table XII-20)

No marked change occurred in the CPUE for skates from the 1960 survey to that of 1970 in the Gulf of Alaska, nor were there marked changes in any of the depth zones. In the various regions, a very large (statistically-significant) decrease was found in the CPUE in the Kenai Region and moderate increases in the Fairweather and **Yakutat** Regions; the other regions saw no marked changes. Individual region-depth zones with large or very large changes were the **Kenai**-outer shelf and Kenai-upper slope with decreases and the Yakutat-upper slope with a large increase. Thus, in comparison with 1960, the 1970 distribution of skates appears to have shifted eastward from the Kenai Region toward **Yakutat** and Fairweather.

b. Turbot (Table XII-21)

No marked change occurred in the CPUE for turbot from 1960 to 1970 in the Gulf of Alaska, and while the upper slope and outer shelf depth zones also saw no marked changes, there was a large (statistically-significant) increase in CPUE in the inner shelf. Among the various regions, a moderate decrease in CPUE occurred in the Fairweather Region; moderate increases in the Yakutat, Prince William, and Kodiak Regions; and a large (statistically-significant) increase in the Sanak Region. Within the region-depth zones a very large decrease was found in the Fairweather-inner shelf, and large or very large increases occurred in the Fairweather-upper slope, Prince William-inner shelf, Sanak-inner shelf, and in the **Sanak**-upper slope.

c. Halibut (Table XII-22)

Length-frequency information collected from catches of halibut made by otter trawls fished at the relatively slow speeds used during these surveys indicate that the trawl does not proportionally sample the large specimens. The comparison of mean CPUES from the surveys in 1960 and 1970, therefore, must be made with reservations.

No marked change in the CPUE for halibut was indicated from 1960 to 1970 in the Gulf of Alaska, and two of the depth zones, the inner shelf and upper slope, also saw no marked changes. On the outer shelf, however, there was a moderate decrease in CPUE. Fairweather, with a moderate decrease, was the only region with a marked change in CPUE from 1960 to 1970. Among the region-depth zones with large or very large changes, were the Kodiak-upper slope, the Chirikof-inner shelf, and the Chirikof-outer shelf with marked decreases.

d. Flathead sole (Table XII-23)

The CPUE for flathead sole did not change markedly within the Gulf of Alaska from the 1960 to the 1970 survey, nor did it change in any of the depth zones. Within the various regions, there were no marked changes except for a moderate decrease in Kenai and a moderate increase in Prince William. Among the region-depth zones with large or very large changes in CPUE were the Fairweather-inner shelf, the Yakutat-upper slope, and the Kodiak-upper slope with decreases, and the Prince William-inner shelf with a very large increase.

e. Dover sole (Table XII-24)

During these resource assessment surveys the depth ranges sampled with respect to Dover sole included only the upper part of the normal distribution of the species. Some reservations, therefore, should be attached to conclusions drawn from comparisons of CPUE between survey periods as reflecting real changes in the entire Dover sole population.

A statistically-significant increase in the CPUE index for Dover sole occurred within the Gulf of Alaska from the 1960 to the 1970 survey, and among the depth zones only the upper slope saw a marked change, a large increase. Within the various regions, moderate increases occurred in Yakutat, Prince William, and Kodiak; and a very large increase took place in the Kenai Region. Among region-depth zones with either large or very large changes, increases occurred in the Yakutat-upper slope, the Prince William-upper slope, the Kenai-outer shelf, the Kenai-upper slope, the Kodiak-upper slope, and the Sanak-upper slope. There appeared to be a widespread increase in CPUE for Dover sole throughout most of the Gulf of Alaska from 1960 to 1970.

f. Rex sole (Table XII-25)

A moderate increase occurred in the CPUE for rex sole in the Gulf of Alaska during the decade from the 1960's to the 1970's. Within the three depth zones, the CPUES for rex sole indicated no marked change in the inner shelf, a moderate increase in the outer shelf, and a large increase in the upper slope. In the regions of the Survey Area, moderate increases occurred in Yakutat, Prince William, and Sanak, and a large increase in Kenai.

Table XII-23.--Ratio of 1970*1960 geometric mean CPUE index (kg/hr)^{1/} for flathead sole.

Species or Species Group	Depth Zone (m)	REGION							Total
		Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak	
Flathead sole	0-100	---	+	+++	<u>2/</u>	0	+	0	0
	101-200	0	0	+		+	0	0	0
	201-400	0	--	0		--	0	<u>2/</u>	0
	Total	0	0	+		0	0	0	0

Table XII-24.--Ratio of 1970%1960 geometric mean CPUE index (kg/hr)^{1/} for Dover sole.

Species or Species Group	Depth Zone (m)	REGION							Total
		Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak	
Dover sole	0-100	<u>2/</u>	0	<u>2/</u>	<u>2/</u>	<u>2/</u>	<u>2/</u>	<u>2/</u>	0
	101-200	0	0	+	+++	+	0	0	0
	201-400	0	*	++	+ + + + - 1 -		0	++	++
	Total	0	+	+	+++	+	0	0	<u>03/</u>

<u>1/</u>	<u>Code</u>	<u>Ratio</u>	<u>Description</u>	<u>2/</u>
	0	0.51-2.00	No marked change, 1960-1970	Insufficient data.
	-	0.26-0.50	Moderate decrease, 1960-1970	<u>3/</u> Significant increase indicated by confidence interval.
	--	0.13-0.25	Large decrease, 1960-1970	
	---	Less than 0.13	Very large decrease, 1960-1970	
	+	2.01-4.00	Moderate increase, 1960-1970	
	-u	4.01-8.00	Large increase, 1960-1970	
	+++	Greater than 8.00	Very large increase, 1960-1970	

Table ,X11-25.--Ratio of 1970+1960 geometric mean CPUE index (kg/hr)^{1/} for rex sole.

Species or Species Group	Depth Zone (m)	REGION							Tot al
		Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak	
Rex sole	0-100		0	+	2/	0	0	0	0
	101-200	+	0	+	++	0	0	*	+
	201-400	+	*	+++	2/	+++	0	++	i-t
	Total	0	+	+	++	0	0	+	+

Table XII-26.--Ratio of 1970+1960 geometric mean CPUE index (kg/hr)^{1/} for rock sole.

Species or Species Group	Depth Zone (m)	REGION							Total
		Fairweather	Yakutat	Prince William	Kena i	Kodiak	Chirikof	Sanak	
Rock sole	0-100		0	0	2/	++		++	o
	101-200	0	2/	2/	2/	o		0	0
	201-400	2/	2/	2/	2/	o	0	2/	o
	Total	0	0	0	2/	1	0	+	0

^{1/} Code	Ratio	Description	^{2/} Insufficient data.
0	0.51-2.00	No marked change, 1960-1970	
-	0.26-0.50	Moderate decrease, 1960-1970	
--	0.13-0.25	Large decrease, 1960-1970	
---	Less than 0.13	Very large decrease, 1960-1970	
+	2.01-4.00	Moderate increase, 1960-1970	
-H-	4.01-8.00	Large increase, 1960-1970	
+++	Greater than 8.00	Very large increase, 1960-1970	

Within the region-depth zones with large and very large changes in CPUE, there were no decreases, but increases occurred in the **Kenai-outer** shelf and in the upper **slopes** in **Yakutat**, Prince William, Kodiak, and **Sanak**. Thus, during the decade, there was a general increase in the density of rex sole throughout most of the Survey Area, especially in the upper slope depth zone.

g. Rock sole (Table XII-26)

No marked change was found in the CPUE for rock sole in the Gulf of Alaska from 1960 to 1970, nor was there a marked change in any of the depth zones. Only two of the regions, Kodiak and Sanak, with moderate increases in CPUE, saw any marked changes from 1960 to 1970. Only 2 region-depth zones had large or very large changes, the Kodiak-inner shelf and Sanak-inner shelf, both with **large** increases. Thus, with the exception of the inner shelf zones of Kodiak and **Sanak**, there was little change in rock sole over the decade from 1960 to 1970.

h. Sablefish (Table XII-27)

The otter trawl surveys of the 1960's and 1970's covered only the upper portion of the bathymetric distribution of sablefish in the Gulf of Alaska; additionally, an unknown part of the population may be found off bottom above the headrope height of the trawl, and the larger fish may be able to avoid the trawl when it is towed at the speeds used during these surveys. Therefore, any changes in the catch rates of sablefish between 1960 and 1970 should be viewed with reservations because availability rather than abundance may be a factor in the difference.

The CPUE for **sablefish** in the Gulf of Alaska did not show a marked change from 1960 to 1970, nor did the CPUE in any of the 3 depth zones. Only 2 of the 7 regions saw any marked changes in sablefish CPUE during the decade; a large decrease in Fairweather and a moderate (statistically-significant) increase in Sanak. Within the region-depth zones with either large or very large changes, there were very large decreases in the FairWeather-inner shelf and in the Fairweather-upper slope along with a large increase in the **Kodiak-**upper slope. Thus, there appears to have been a general decline in the density of **sablefish** in the eastern part of the Survey Area from 1960 to 1970,

i. Cottids (Table XII-28)

No marked change in the CPUE for **cottids** was found from 1960 to 1970 within the Gulf of Alaska, in the 3 depth zones, or in 4 of the 7 regions. Two of the regions, **Chirikof** and Sanak, showed moderate decreases, and in 1 region, Prince William, there was a moderate increase. Among the region-depth zones with either large or very large changes in the CPUE for cottids were the outer shelf zones of Chirikof and Sanak which had large decreases and the upper slopes of Prince William and Kodiak with large increases. Thus, there were general decreases in CPUE for **cottids** in the western **extreme** of the Survey Area and some increases in the central part.

Table xII-27. --Ratio of 1970÷1960 geometric mean CPTJE index (kg/hr)^{1/} for sablefish.

Species or Species Group	Depth Zone (m)	REGION							Total
		Fairweather	Yakutat	Prince William	Kena i	Kodiak	Chirikof	Sanak	
Sablefish	0-100	---	0	2/	<u>2/</u>	<u>2/</u>	<u>2/</u>	2/	0
	101-200			0	0	0	0	0	0
	201-400	---	+	0		<u>2/</u>		+	0
	Total	--	0	0	0	0	0	+3/	0

Table XII-28 .--Ratio of 1970÷1960 geometric mean CPUE index (kg/hr)^{1/} for cottids.

Species or Species Group	Depth Zone (m)	REGION							Total
		Fairweather	Yakutat	Prlnce William	Kena i	Kodiak	Chirikof	Sanak	
Cottids	0-100	<u>2/</u>	0	<u>2/</u>	<u>2/</u>	0		0	0
	101-200	0	<u>2/</u>	+	0		--	--	0
	201-400	+	<u>2/</u>	++	<u>2/</u>	-H-			0
	Total	0	0	+	0	0			0

^{1/} Code

Code	Description
0	0.51-2.00 No marked change, 1960-1970
--	0.26-0.50 Moderate decrease, 1960-1970
---	0.13-0.25 Large decrease, 1960-1970
+	Less than 0.13 Very large decrease, 1960-1970
H	2.01-4.00 Moderate increase, 1960-1970
-H-!	4.01-8.00 Large increase, 1960-1970
	Greater than 8.00 Very large increase, 1960-1970

^{2/} Insufficient data.

^{3/} Significant increase indicated by confidence interval.

j. Pacific cod (Table XII-29)

Since the Pacific cod is known to be semi-pelagic, a portion of the population may occur off bottom and be unavailable to the otter trawls employed in the 1960 and 1970 surveys. Therefore, some of the differences in CPUE noted between the results of the surveys may be because of changes in availability rather than because of changes in abundance, and these data should be viewed with that reservation.

The CPUE for Pacific cod showed no marked change from the 1960's to the 1970's in the Gulf of Alaska but did indicate a moderate increase in the inner shelf depth zone. Within the regions there was a moderate decrease in CPUE in Fairweather; and moderate increases occurred in Prince William, Kodiak, Chirikof, and Sanak. The region-depth zones with large or very large changes in the CPUE for Pacific cod were as follows: decreases occurred in the Fairweather-inner shelf and the Kodiak-upper slope, and increases occurred in the Yakutat-inner shelf, the Prince William-outer shelf, the Kodiak-inner shelf, the Kodiak outer shelf, the Chirikof-upper slope, and the Sanak-outer shelf.

k. Walleye pollock (Table XII-30)

Walleye pollock are known to be semi-pelagic, and an unknown portion of the population may have been off bottom and unavailable to the otter trawls during the 1960 and 1970 surveys. The differences in mean CPUE between surveys, therefore, may be due in part to differences in availability rather than a reflection of actual differences in relative abundance.

There was a large (statistically-significant) increase in the density index for pollock between the 1960 and 1970 surveys in the Gulf of Alaska. In the depth zones there was a large increase in the CPUE for pollock in the inner shelf, a very large (statistically-significant) increase in the outer shelf, and no marked change in the upper slope. Within the various regions, there were decreases in the CPUE in none; no marked change in Fairweather, moderate increases in Yakutat and Kenai; and very large (statistically-significant) increases in Prince William, Kodiak, and Chirikof. In the Sanak Region the very large increase was not statistically-significant. Among the region-depth zones with large or very large changes, all such changes were increases and occurred in the inner shelf depth zones of Yakutat, Prince William, Kodiak, and Sanak; in the outer shelf depth zones of Prince William, Kenai, Kodiak, Chirikof, and Sanak; and in the upper slope zones of Kodiak and Sanak. Thus, there was a general increase in pollock throughout most of the Gulf of Alaska in the inner and outer shelf depth zones except in the eastern extreme.

1. Pacific ocean perch (Table XII-31)

The Pacific ocean perch is known to be semi-pelagic, and therefore a portion of the population may have been distributed in the water above the headrope of the otter trawl. This species is also known to occur over rough, rocky substrata unsampleable by otter trawls as rigged during these surveys. Therefore, the CPUE estimates made may be minimal and possibly biased so they should be viewed with caution.

Table xII-29. --Ratio of 1970÷1960 geometric mean CPUE index (kg/hr)^{1/} for Pacific cod,

Species or Species Group	Depth Zone (m)	REGION							Total
		Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak	
Pacific cod	0-100	---	i-t	+	<u>2/</u>	++	0	+	+
	101-200	0	0	++	0	++	0	i-t	0
	201-400	<u>2/</u>	0	0	0	--	++	+	0
	Total		0	+	0	+	+	+	0

Table XII-30. --Ratio of 1970÷1960 geometric mean CPUE index (kg/hr)^{1/} for walleye pollock.

Species or Species Group	Depth Zone (m)	REGION							Total
		Fairweather	Yakutat	Prince William	Kena i	Kodiak	Chirikof	Sanak	
Walleye pollock	0-100		+++	+++	<u>2/</u>	1-1-1-	+	i-t	-t-t
	101-200	0	0	+++	+++	+++	+++	+++	+++ <u>3/</u>
	201-400	0	0	0	0	+++	0	+++	0
	Total	0	+	+++ <u>3/</u>	+	+++ <u>3/</u>	+++ <u>3/</u>	+++	+++ <u>3/</u>

<u>1/</u> Code	Ratio	Description
o	0.51-2.00	No marked change, 1960-1970
	0.26-0.50	Moderate decrease, 1960-1970
--	0.13-0.25	Large decrease, 1960-1970
---	Less than 0.13	Very large decrease, 1960-1970
+	2.01-4.00	Moderate increase, 1960-1970
++	4.01-8.00	Large increase, 1960-1970
+++	Greater than 8.00	Very large increase, 1960-1970

2/ Insufficient data.3/ Significant increase indicated by confidence interval.

Table XII-31.--Ratio of ~~1970÷1960~~ geometric mean CPUE index (kg/hr)^{1/} for Pacific ocean perch.

Species or Species Group	Depth Zone (m)	REGION							Total
		Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak	
Pacific ocean perch	0-100	<u>2/</u>	0	<u>2/</u>	<u>2/</u>	<u>1/</u>	<u>2/</u>	<u>2/</u>	0
	101-200				--			<u>2/</u>	-
	201-400	---	---	---	---	+	---		---
	Total				---	0		0	<u>-4/</u>

Table XII-32.--Ratio of ~~1970÷1960~~ geometric mean CPUE index (kg/hr)^{1/} for Tanner crab.

Species or Species Group	Depth Zone (m)	REGION							Total
		Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak	
Tanner crab	0-100		+	+++	<u>2/</u>	0	0	0	+
	101-200	--	0	++	---	.	0	0	0
	201-400	<u>2/</u>	--	++	---	---	0	<u>2/</u>	-
	Total	--	0	+++	---		0	0	0

<u>1/ Code</u>	<u>Ratio</u>	<u>Description</u>	<u>2/ Insufficient data.</u>
0	0.51-2.00	No marked change, 1960-1970	
	0.26-0.50	Moderate decrease, 1960-1970	
--	0.13-0.25	Large decrease, 1960-1970	
---	Less than 0.13	Very large decrease, 1960-1970	
+	2.01-4.00	Moderate increase, 1960-1970	
+1-	4.01-8.00	Large increase, 1960-1970	
+++	Greater than 8.00	Very large increase, 1960-1970	

4/ Significant decrease indicated by confidence interval.

There was a moderate (statistically-significant) decrease **in CPUE** for Pacific ocean perch within the Gulf of Alaska as a whole. Among the depth zones there was no marked change in the inner shelf, a moderate decrease in the outer shelf, and a very large (statistically-significant) decrease in the upper slope. Within the regions, there were no marked changes **in CPUE** for Pacific ocean perch in Sanak and Kodiak; moderate decreases occurred in **Fairweather**, **Yakutat**, **Prince William**, and **Chirikof**; and a very large decrease occurred in **Kenai**. Among the region-depth zones with large or very large changes there were decreases in the Kenai-outer shelf and in the upper slope zones of **Fairweather**, **Yakutat**, **Prince William**, **Kenai**, **Chirikof**, and **Sanak**. Thus, the **CPUE** for Pacific ocean perch generally declined within the Gulf of Alaska from 1960 to 1970.

m. Tanner crab (Table XII-32)

Otter trawls towed at the $2\frac{1}{2}$ - 3 knots speeds utilized during these surveys are apparently more effective at capturing female and small male Tanner crab than at catching large males. Therefore, the comparisons of mean **CPUEs** for the 1960's and 1970's may be biased with reference to those parts of the stocks which are harvested commercially.

There was no marked change in the CPUE for Tanner crab within the Gulf of Alaska during the decade from 1960 to 1970. Within the three depth zones there was a moderate increase in the inner shelf, and a moderate decrease occurred in the upper slope. Among the 7 regions there were no marked changes in CPUE in **Yakutat**, **Chirikof**, and Sanak; a moderate decrease in Kodiak; a large decrease in Fairweather, a very large decrease in **Kenai**; and a very large increase in Prince William. Region-depth zones with either large or very large changes in the CPUE for Tanner crab are as follows: decreases occurred in the FairWeather-outer shelf, the Yakutat-upper slope, the Kenai-outer shelf, the Kenai-upper slope, and the Kodiak upper slope; increases occurred in all 3 of the Prince William depth zones. Thus, only in the Prince William region were there marked **increases** in the CPUE for Tanner crab from 1960 to 1970.

n. King crab (Table XII-33)

Otter trawls towed at the $2\frac{1}{2}$ - 3 knots speeds utilized during these surveys are apparently more effective at the capture of female and small male king crab than at catching large males. Therefore, the comparisons of mean CPUES for the 1960's and 1970's may be biased in estimating catch rates for that part of the population which is fished commercially.

There was no marked change in CPUE for king crab in the decade from 1960 to 1970 in the Gulf of Alaska as a whole. Within the 3 depth zones there were also no marked changes. Among the various regions, there was no marked change from 1960 to 1970 in Fairweather; moderate decreases occurred in Kodiak and **Chirikof**; and a large increase took place in Sanak. The region-depth zones with large or very large changes in CPUE from 1960 to 1970 were the Kodiak-upper slope and the **Chirikof-inner** shelf with decreases and the **Sanak-inner** shelf and the **Sanak-outer** shelf with increases. A general increase in king crab appears to have occurred in the 2 Sanak shelf zones while all depth zones in the **Chirikof** Region and the two deeper zones in Kodiak indicated decreases.

Table XII-33.--Ratio of 1970÷1960 geometric mean CPUE index (kg/hr)^{1/} for king crab.

Species or Species Group	Depth Zone (m)	REGION							Total
		Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	S anak	
King crab	o-100	<u>2/</u>	<u>2/</u>	<u>2/</u>	<u>2/</u>	o	---	+1-	0
	101-200	0	<u>2/</u>	<u>2/</u>	<u>2/</u>			i-l-	0
	201-400	---	<u>2/</u>	<u>2/</u>	<u>2/</u>	---		<u>2/</u>	0
	Total	<u>2/</u>	<u>2/</u>	<u>2/</u>	<u>2/</u>			++	0

1/ Code

0

0.51-2.00

No marked change, 1960-1970

0.26-0.50

Moderate decrease, 1960-1970

0.13-0.25

Large decrease, 1960-1970

Less than 0.13

Very large decrease, 1960-1970

+

2.01-4.00

Moderate increase, 1960-1970

++

4.01-8.00

Large increase, 1960-1970

+++

Greater than 8.00

Very large increase, 1960-1970

2/ Insufficient data.

4/ Significant decrease indicated by confidence interval.

DISTRIBUTION OF BIOMASS BY DEPTH ZONE IN 1960 AND 1970

Within the Survey Area, the mean biomass in the 1960 survey was 8.9 mt/km² (Table XI-9) as compared with 10.6 mt/km² (Table XI-104) in the 1970 survey, an increase of 19.1 percent. By depth zone the greatest biomass density occurred in the 1960 survey in the upper slope (9.9 mt/km²) followed by the outer shelf (9.2 mt/km²) and the inner shelf (8.1 mt/km²); in the 1970 surveys the outer shelf had the greatest density (12.7 mt/km²) followed by the inner shelf (9.6 mt/km²), and the upper slope (7.4 mt/km²). Thus, the upper slope mean density declined by 25 percent from 1960 to 1970 and changed that zone's ranking from first in 1960 to last in 1970.

DISTRIBUTION OF BIOMASS BY REGION IN 1960 AND 1970

The distribution of biomass in the regions of the Gulf of Alaska varied considerably between the 1960 and 1970 surveys (Table XII-34). The FairWeather Region had the greatest density of any in 1960 (20.4 mt/km²) and the least in 1970 (5.4 mt/km²). The biomass density in the Prince William Region increased 3-fold from 2.5 mt/km² in 1960 to 7.8 mt/km² in 1970. In the Sanak Region the density increased from 6.7 mt/km² in 1960 to 18.4 mt/km² in 1970--nearly 3-fold. In the Kodiak Region the biomass nearly doubled from 1960 (9.7 mt/km²) to 1970 (18.6 mt/km²).

RANKING OF PROMINENT SPECIES WITHIN THE GULF OF ALASKA ON THE BASIS OF CATCH PER UNIT EFFORT IN 1960 AND 1970

In the Survey Area as a whole the rank order of species by CPUE in the 1960 survey and again in 1970 is listed in Table XII-35. The more dramatic changes from 1960 to 1970 include the declines in king crab (72.3 to 18.9 kg/hr), cottids (40.3 to 21.6 kg/hr), Pacific ocean perch (36.8 to 3.9 kg/hr), and sablefish (7.9 to 4.2 kg/hr) and the increases in flathead sole (31.0 to 43.7 kg/hr), rock sole (29.2 to 46.9 kg/hr), walleye pollock (15.9 to 320.5 kg/hr), rex sole (4.1 to 19.7 kg/hr), and Dover sole (2.9 to 19.3 kg/hr). Thus, there were general increases in most of the flatfish from 1960 to 1970 accompanied by a 20-fold increase in the walleye pollock, a roundfish. During the same period another roundfish, the sablefish, and a prominent rockfish, the Pacific ocean perch, decreased.

In the 0-100 m depth zone the rankings of species by CPUE in the 1960 survey and in the 1970 survey are shown in Table XII-36. A sharp decrease occurred in the CPUE for king crab (179.6 to 23.3 kg/hr), but there were moderate increases in rock sole (73.0 to 147.2 kg/hr), Pacific cod (30.3 to 81.7 kg/hr), and turbot (21.7 to 43.4 kg/hr), and large increases in walleye pollock (3.0 to 108.9 kg/hr), and skates (1.8 to 10.5 kg/hr).

In the 101-200 m depth zone, the CPUE rankings of the prominent species in 1960 and 1970 are listed in Table XII-37. The decade between the surveys saw decreases in the stock of Tanner crab (64.5 to 35.6 kg/hr), Pacific ocean perch (50.1 to 6.1 kg/hr), cottids (48.1 to 14.0 kg/hr), sablefish (7.3 to 2.1 kg/hr), and shortspine thornyhead (3.2 to 1.1 kg/hr). During this same period the CPUEs for other species were increasing: walleye pollock (23.9 to 528.7 kg/hr), Dover sole (0.8 to 14.2 kg/hr), king crab (14.7 to 23.6 kg/hr), and rex sole (3.4 to 18.7 kg/hr).

Table XII-34. --**Estimated biomass in metric tons** per square **kilometer** during the 1960 and 1970 resource assessment surveys in the **Gulf of Alaska**.

Region	1960		1970	
	mt /km ²	Rank	mt/km ²	Rank
Fairweather	20.4	1	5.4	8
Yakutat	9.0	5	7.5	5
Prince William	2.5	9	7.8	4
Kenai	9.2	4	6.7	6
Kodiak	9.7	3	18.6	1
Shelikof	6.3	7	5.7	7
Chirikof	11.4	2	9.5	3
Shumagin	5.8	8	--	--
Sanak	6.7	6	18.4	2
Total	8.9		10.9	

Table X11-35.--Fifteen most prominent species in the 1960 **and** 1970 resource assessment surveys in the Gulf of Alaska (**all** depth zones and regions combined).

1960 (kg/hr)	1970 (kg/hr)
Turbot (91.0)	Walleye pollock (320.5)
King crab (72.3)	Turbot (82.8)
Tanner crab (47.9)	Pacific cod (47.6)
Pacific cod (43.6)	Rock sole (46.9)
Cottids (40.3)	Flathead sole (43.7)
Pacific ocean perch (36.8)	Tanner crab (36.9)
Flathead sole (31.0)	Cottids (21.6)
Rock sole (29.2)	Rex sole (19.7)
Halibut (20.7)	Dover sole (19.3)
Walleye pollock (15.9)	King crab (18.9)
Skates (9.5)	Halibut (18.0)
Sablefish (7.9)	Skates (11.2)
Rex sole (4.1)	Shortspine thornyhead (4.9)
Shortspine thornyhead (3.2)	Sablefish (4.2)
Dover sole (2.9)	Pacific ocean perch (3.9)

Table XII-36. --Fifteen most prominent species in the 0-100 m depth zone in the 1960 and 1970 resource assessment surveys in the Gulf of Alaska (all regions combined).

1960 (kg/hr)	1970 (kg/hr)
King crab (179.6)	Rock sole (147.2)
Rock sole (73.0)	Walleye pollock (108.9)
Cottids (46.4)	Pacific cod (81.7)
Halibut (35.1)	Cottids (49.0)
Tanner crab (32.6)	Turbot (43.4)
Pacific cod (30.3)	Tanner crab (34.1)
Turbot (21.7)	Halibut (28.6)
Flathead sole (10.4)	King crab (23.3)
Walleye pollock (3.0)	Flathead sole (15.4)
Skates (1.8)	Skates (10.5)
Rex sole (1.5)	Rex sole (4.0)
Pacific ocean perch (1.1)	Smelts (0.8)
Sablefish (0.9)	Dover sole (0.5)
Dover sole (0.1)	Shortspine thornyhead (0.5)
Shortspine thornyhead (0.0)	Sablefish (0.4)

Table XII-37. --Fifteen most prominent species in the 101-200 m depth zone in the 1960 and 1970 resource assessment surveys in the Gulf of Alaska (all regions combined).

1960 (kg/hr)	
Turbot (103.3)	Walleye pollock (528.7)
Pacific cod (65.6)	Turbot (90.9)
Tanner crab (64.5)	Flathead sole (61.2)
Pacific ocean perch (50.1)	Pacific cod (41.2)
Cottids (48.1)	Tanner crab (35.6)
Flathead sole (43.6)	King crab (23.6)
Walleye pollock (23.9)	Rex sole (18.7)
Halibut (15.0)	Dover sole (14.2)
King crab (14.7)	Cottids (14.0)
Skates (11.7)	Skates (12.3)
Sablefish (7.3)	Rock sole (10.8)
Rock sole (6.4)	Halibut (9.9)
Rex sole (3.4)	Pacific ocean perch (6.1)
Dover sole (0.8)	Smelts (2.9)
Shortspine thornyhead (0.8)	Sablefish (2.1)

In the 201-400 m depth zone the most prominent species in terms of catch per unit of effort in 196(.) and 1970 are listed in **Table XII-38**. Between the 2 surveys there were sharp decreases in turbot (206.8 to 119.1 kg/hr), Pacific ocean perch (76.5 to 3.4 kg/hr), sablefish (26.5 to 13.4 kg/hr), and king crab (7.1 to 3.6 kg/hr). Increases occurred in walleye pollock (20.3 to 103.4 kg/hr), Pacific cod (7.4 to 22.4 kg/hr), halibut (6.2 to 23.1 kg/hr), and rock sole (0.4 to 5.1 kg/hr).

XIII SUMMARY

Included in this report is a description of the **Survey Area**, a 2,200 kilometer long arc in the Gulf of Alaska from Cape Spencer to **Unimak Pass**. The area contains 220,000 km² of which 36% is in the 0-100 m depth zone, 48% in the 101-200 m depth zone, and 16% in the 201-400 m depth zone.

The fish and invertebrate fauna are described. The fishes include 287 species belonging to 55 families. The invertebrate fauna is less well defined than the fish fauna, but 13 commercially-valuable species from 5 families are included.

Informational sources that have been analyzed for the report include both research reports and the commercial fisheries data. Research sources include exploratory fishing cruises and resource assessment surveys. Commercial fisheries sources include both domestic and foreign catch statistics.

Commercial exploitation of demersal resources in the Gulf of Alaska has been carried out by nationals of the United States, Canada, Japan, the Soviet Union, South Korea, Poland, and Taiwan. The more important fisheries for the Americans have been those for king crab, Tanner (snow) crab, Pandalid shrimp, and scallops. A joint fishery by American and Canadian fishermen for halibut has endured for many years. Japanese and Soviet fishermen have generally pursued fin fishes other than halibut as well as shrimp. Fishing by the Koreans, Poles, and Taiwanese has been relatively minor thus far.

Exploratory fishing cruises were conducted in the Survey Area from 1948 through 1970. Pandalid shrimp surveys to determine their distribution and to estimate stock magnitude took place from 1971 through 1976. Demersal fish resource assessment surveys were made from 1961 to 1962 and from 1973 to 1976. These surveys differed from exploratory fishing operations in that the surveys were designed to provide estimates of the magnitude, distribution, and composition of resources whereas exploratory fishing had as its objective the discovery of locales of favorable fishing conditions.

Comparisons between the results of resource abundance surveys in the Gulf of Alaska during 1961 and those in 1973-1976, indicate a **statistically-significant** increase in walleye pollock and Dover sole, and a decrease in Pacific ocean perch. Changes in CPUE from the 1960's to the 1970's were noted in each of 7 regions of the Survey Area, 3 depth zones, and 21 region-depth zones. Comparison between the 1960 and 1970 surveys was also made with reference to the distribution of biomass and rank order of prominent species in catch per km², both of which varied widely and suggested that dramatic changes have occurred over the years.

Table xII-38 ,--Fifteen **most prominent** species in the 201-400 m depth zone in the 1960 and 1970 resource assessment surveys in the Gulf of Alaska (all regions combined).

1960 (kg/hr)	1970 (kg/hr)
Turbot (206.8)	Turbot (119,1)
Pacific ocean perch (75.6)	Walleye pollock (103.4)
Flathead sole (38.9)	Dover sole (52.1)
Tanner crab (32.5)	Tanner crab (42.4)
Sablefish (26.5)	Flathead sole (40.7)
Walleye pollock (20.3)	Rex sole (40.3)
Skates (19.9)	Halibut (23.1)
Shortspine thornyhead (17,5) ⁰	Pacific cod (22.4)
Dover sole (15.6)	Shortspine thornyhead (17.8)
Rex sole (13.1)	Sablefish (13.4)
Pacific cod (7.4)	Skates (11.5)
King crab (7.1)	Rock sole (5.1)
Halibut (6.2)	Cottids (4.9)
Cottids (4.0)	King crab (3.6)
Rock sole (0.4)	Pacific ocean perch (3.4)

XIV

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APPENDICES

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APPENDIX A
GAZETTEER

Table 1.--Latitudes, longitudes and brief descriptions of geographic features mentioned in the text.

Aialik Bay	59°50'N - 149°43'W
An inlet along the south coast of Kenai peninsula	
Aliulik Peninsula	56°49 'N - 154°00'W
The peninsula which forms the southwest corner of Kodiak Island	
Afognak Island	59°13'N - 152°35'W
A large island immediately northeast of Kodiak Island	
Albatross Bank	north: 57°15'N - 151°45'W
	middle: 56°40'N - 152°05'W
	south, 56°20'N - 153°05'W
A series of three banks south of Kodiak Island	
Alitak Bay	56°55'N - 154°00'W
A bay in southwest Kodiak Island	
Amatuli Island	58°55'N - 152°00'W
One of the Barren Islands at the mouth of Cook Inlet	
Beaver Bay	55°30'N - 160°55'W
An inlet <i>in</i> southern Alaska Peninsula inside of Unga Island	
Belkofski Bay	55°05'N - 162°10'W
A bay in the south coast of southern Alaska Peninsula	
Blying Bank	59°30'N - 148°45'W
A bank south of Kenai peninsula 25 miles southwest of Cape Cleare	

Cape Cleare	59°45'N - 147°53'W
The southwest tip of Montague Island	
Cape Douglas	58°50'N - 153°15'W
The easternmost point of Alaska Peninsula, mouth of Cook Inlet	
Cape Elizabeth	59°10'N - 151°53'W
The southwest tip of Kenai Peninsula, mouth of Cook Inlet	
Cape Hinchinbrook	60°14'N - 146°37'W
The southwest tip of Hinchinbrook Island	
Cape Kiavak	57°00'N - 153°33'W
A cape on the western shore of Aliutik Peninsula, south Kodiak	
Cape Saint Elias	59°88'N - 144°25'W
The southwestern point of Kayak Island, 60 miles southeast of prince William Sound	
Cape Spencer	58°12'N - 136°38'W
A point at the northern entrance to the inside waters of southeast Alaska	
Cape Suckling	59°59'N - 143°55'W
A point in the south Alaska coast between Icy Bay and Prince William Sound	
Castle Bay	56°10'N - 158°15'W
An inlet in the south coast of Alaska Peininsula	
Chignik Bay	56°20'N - 158°20'W
A bay in the south coast of Alaska Peninsula	

- Chignik Gully** **57°30'N - 151°30'W**
 A depression running southwest from **Chiniak** Bay, Kodiak Island
- Chirikof Island** **55°50'N - 155°40'W**
 An island 70 miles southwest of Kodiak Island
- Cook Inlet** **60°00'N - 152°00'W**
 A large inlet **in** south **Alaska** between **Kenai** and Alaska Peninsulas
- Day Harbor** **59°57' N - 149°10'W**
An inlet in the south coast of **Kenai** Peninsula
- Dry Bay** **57°38'N - 155°42'W**
 A bay in the south coast of **Alaska** Peninsula at the mouth of **Shelikof** Straits
- Hinchinbrook Entrance** **60°19'N - 146°50'W**
 The passage between **Hinchinbrook** and Montague Islands
- Hinchinbrook Gully** **59°55'N - 147°05'W**
 A depression running south from **Hinchinbrook** Entrance
- Hinchinbrook Island** **60°25'N - 146°25'W**
An island in the mouth of Prince William Sound .
- Icy Bay** **59°55'N - 141°25'W**
 A bay in the south Alaska coast between **Yakutat** Bay and Cape Suckling
- Ikatan Bay** **54°48'N - 163°16'W**
 A bay between Alaska Peninsula and **Unimak** Island

Jack Bay	60°02'N - 146°37'W
A thin arm of northeast Prince William Sound	
Kachemak Bay	59°35'N - 151°25'W
An arm of lower Cook Inlet in the west shore of Kenai Peninsula	
Kayak Island	59°54'N - 144°25'W
A long island offshore of Cape Suckling	
Kenai Peninsula	60°00'N - 150°00'W
The major peninsula between Cook Inlet and Prince William Sound	
Kiluda Bay	57°19'N - 153°00'W
A bay on the south coast of Kodiak Island	
Kodiak Island	57°25'N - 154°15'W
A large island south of Upper Alaska Peninsula	
Kuiukta Bay	56°06'N - 158°38'W
A bay in the south coast of Alaska Peninsula	
Kujalik Bay	56°37'N - 157°49'W
A bay in the south coast of Alaska Peninsula	
Kukak Bay	58°19'N - 154°15'W
An arm of Shelikof Strait extending into Alaska Peninsula	
Lituya Bay	58°38'N - 137°34'W
An inlet in the Alaska coast about 45 miles northwest of Cape Spencer	

Marmot Bay	58°00'N - 152°20'W
A bay between Kodiak and Afognak Islands	
Marmot Gully	58°11'N - 151°20'W
A depression extending east from Marmot Bay	
Middleton Island	59°26'N - 146°19'W
An island 60 miles south of Prince William Sound	
Mitrofanía Bay	55°54'N - 158°58'W
A bay in the south shore of Alaska Peninsula	
Mitrofanía Gully	55°37'N - 158°55'W
A depression running south from between Mitrofanía and Chiach Islands (South Alaska Peninsula)	
Mitrofanía Island	55°52'N - 158°48'W
A small island off the south coast of Alaska Peninsula	
Montague Gully	59°30'N - 148°12'W
A depression extending south from the Montague Straits	
Montague Island	60°00'N - 147°26'W
A long island in the mouth of Prince William Sound	
Montague Straits	60°07'N - 147°38'W
The waters between Montague Island and Letouche and Knight Islands	
Morzhovoi Bay	55°02'N - 163°05'W
A bay in the southern tip of Alaska Peninsula	

Nagai Island	55°08'N - 159°58'W
One of the Shumagin Islands , south of Alaska Peninsula	
Nagai Straits	55°22'N - 159°44'W
The straits between Nagai , Andronica and Big Koniuji Islands (Shumagin Islands)	
Nuka Bay	59°27'N - 150°30'W
A bay in the south coast of Kenai Peninsula	
Nuka Passage	59°22'N - 150°45'W
The strait on the west side of Nuka Island (south Kenai)	
Ocean Cape	59°32'N - 139°53'W
A point at the mouth of Yakutat Bay	
Orca Bay	60°35'N - 146°05'W
An arm of the east side of Prince William Sound	
Otter Cove	54°48'N - 163°22'W
A small embayment in the southeast corner of Unimak Island	
Pavlof Bay	55°30'N - 161°35'W
A bay in the south end of Alaska Peninsula	
Pernosa Bay	58°24'N - 152°15'W
A bay in the northeast corner of Afognak Island	
Port Bainbridge	60°05'N - 148°25'W
A bay in the Kenai Peninsula next to the mouth of Prince William Sound	

Port Dick	59°16'N - 151°04'W
An inlet in the south coast of Kenai Peninsula	
Port Fidalgo	60°48'N - 146°20'W
An arm of eastern Prince William Sound	
Port Gravina	60°42'N - 146°20'W
An arm of eastern Prince William Sound	
Portlock Bank	58°21'N - 150°30'W
A large bank south of Kenai Peninsula and west of Kodiak Island	
Port Valdez	61°05'N - 146°39'W
An arm of northeastern Prince William Sound	
Prince William Sound	60°38'N - 147°23'W
A large embayment in the south coast of Alaska, east of Kenai Peninsula	
Pye Islands	59°26'N - 150°25'W
Three small islands south of Kenai Peninsula	
Raspberry Straits	58°05'N - 153°05'W
A narrow channel along the southwest side of Afognak Island	
Sanak Gully	54°20'N - 162°24'W
A depression running between Deer and Sanak Islands	
Sanak Island	54°25'N - 162°40'W
An island 40 miles south of the tip of Alaska Peninsula	
Scotch Cap	54°24'N - 164°44'W
The southwest corner of Unimak Island	

Semidi Islands	56°05'N - 156°45'W
A group of islands between Chirikof Island and Alaska Peninsula	
Seward Gully	59°25'N - 149°07'W
A depression running southward from Kenai Peninsula	
Shelikof Strait	58°00'N - 154°00'W
A group of islands south of Alaska Peninsula	
Shumagin Islands	55°10'N - 160°00'W
A group of islands south of Alaska Peninsula	
Shuyak Island	58°32'N - 152°30'W
An island northeast of Afognak Island	
Sitkalidak Island	57°06'N - 153°10'W
An island off the south coast of Kodiak Island	
Sitkinak Island	56°34'N - 154°09'W
An island off the southwest corner of Kodiak Island	
Stepovak Bay	55°42'N - 159°45'W
A bay in the south coast of Alaska Peninsula	
Tonki Bay	58°19'N - 152°04'W
A bay in the west shore of A. .nak Island	
Tonki Cape	58°21'N - 151°59'W
A point on the northeast corner of Afognak Island	

Trinity Islands 56°33'N - 154°24'W

Two islands off the southwest corner of Kodiak Island

Uganik Bay 57°52'N - 153°34'W

A bay in the ~~north~~ coast of Kodiak Island

Unga Island 55°20'N - 160°44'W

The most westerly of the **Shumagin** Islands

Unga Strait 55°25'N - 160°34'W

The most westerly of the **Shumagin** Islands

Unimak Bight 54°34'N - 164°00'W

The wide bay formed by the south coast of **Unimak** Island

Unimak Pass 54°25'N - 165°15'W

The pass between **Unimak** Island and the **Krenitzen** Island group

Ushagat Island 59°07'N - 152°18'W

One of the Barren Islands at the mouth of Cook Inlet

Uyak Bay 57°39'N - 153°56'W

A bay **in** the north coast of Kodiak Island

Viekoda Bay 57°55'N - 153°20'W

A bay in the north coast of Kodiak Island

Yakutat Bay 59°45'N - 140°00'W

A large bay on the south coast of Alaska between Cape Spencer and
Icy Bay

Yakutat Gully 59°30'N - 141°00'W

A depression extending southwest from Yakutat Bay

APPENDIX B

Variances of the biomass estimates by regions, depth zones, and surveys

Table 1---Variances of the Biomass estimates **for the** Fairweather region for May-October 1961, Cr 611.

Species	Depth Zones (m)			Total
	0-100	101-200	201-400	
Elasmobranchs	.354253x10 ¹¹	.874543x10 ¹²	.294161x10 ¹²	.120412x10¹³
Flatfishes	.293278x10 ¹⁴	.276017x10 ¹⁶	.160562x10 ¹⁴	.280556x10¹⁶
Roundfishes	.152248x10 ¹⁵	.478686x10¹³	.903261x10 ¹³	.177168x10¹⁵
Rockfishes	.116858x10⁹	.293174x10 ¹²	.984767x10 ¹³	.101409x10¹⁴
Invertebrates	.549537x10 ¹²	.318586x10 ¹⁶	.649536x10 ¹⁴	.325136x10 ¹⁶
Skates	.320733x10 ¹¹	.824144x10 ¹²	.312766x10 ¹²	.116898x10 ¹³
Turbot	.334772x10 ¹⁴	.250713x10 ¹⁵	.150718x10 ¹³	.285697x10 ¹⁵
Halibut	.178589x10 ¹²	.269128x10 ¹²	0.	.447718x10 ¹²
Flathead sole	.222059x10 ¹⁴	.282509x10 ¹⁴	.123307x10 ¹⁴	.516899x10 ¹⁴
Dover sole	.386309x10 ⁹	● 100143x10 ¹²	.382202x10 ¹³	.392255x10 ¹³
Rex sole	.845666x10 ¹¹	.916256x10 ¹¹	.102687x10 ¹³	.120306x10 ¹³
Rock sole	.110493x10 ¹²	.666601x10¹¹	0.	.177153x10 ¹²
Sablefish	.737995x10 ¹¹	.275271x10 ¹³	.860100x10 ¹³	.114275x10 ¹⁴
Cottidae	0.	.731725x10 ¹¹	.177013x10 ⁹	.733495x10 ¹¹
Pacific cod	.150125x10 ¹⁵	.926796x10 ¹²	.163737x10¹⁰	.161053x10 ¹⁵
Walleye pollock	.742377x10¹⁰	.123713x10 ¹¹	.158503x10 ¹¹	.356455x10 ¹¹
Thornyheads	0.	.498617x10¹⁰	.175160x10 ¹³	.175659x10¹²
Pacific ocean perch	0.	.261071x10 ¹²	.820791x10 ¹³	.846898x10¹³
Tanner crab	.566596x10 ¹¹	.472501x10 ¹⁴	.610642x10 ¹¹	.473678x10 ¹⁴
King crab	0.	.359027x10 ⁹	.101558x10 ¹¹	.105148x10 ¹¹

Table 2.--Variances of the biomass estimates for the Yakutat region for May-October 1961, Cr 611.

Species	Depth Zones (m)			Total
	0-100	101-200	201-400	
Elasmobranchs	.239225x10 ¹²	.839940x10 ¹²	.260847x10 ¹²	.134001x10 ¹³
Flatfishes	.225766x10 ¹⁴	.309605x10 ¹⁴	.310893x10 ¹⁴	.846265x10 ¹⁴
Roundfishes	.242177x10 ¹³	.391241x10 ¹³	.536025x10 ¹²	.687021x10 ¹³
Rockfishes	.591767x10 ⁸	.454031x10 ¹⁴	.875550x10 ¹³	.541586x10 ¹⁴
Invertebrates	.246621x10 ¹⁴	.454019x10 ¹⁴	.119348x10 ¹⁵	.189412x10 ¹⁵
Skates	.357628x10 ¹¹	.171013x10 ¹²	.265499x10 ¹²	.472275x10 ¹²
Turbot	.524319x10 ¹³	.157634x10 ¹⁴	.152100x10 ¹⁴	.362167x10 ¹⁴
Halibut	.184870x10 ¹²	.226678x10 ¹²	.134470x10 ¹²	.546019x10 ¹²
Flathead sole	.165360x10 ¹²	.204696x10 ¹³	.429999x10 ¹²	.264232x10 ¹³
Dover sole	.515490x10 ⁸	.334524x10 ¹¹	.296193x10 ¹³	.299543x10 ¹³
Rex sole	.778910x10 ¹¹	.131029x10 ¹²	.152655x10 ¹³	.173547x10 ¹³
Rock sole	.711872x10 ¹⁰	.752981x10 ¹⁰	0.	.146485x10 ¹¹
Sablefish	.615759x10 ¹¹	.132435x10 ¹³	.214482x10 ¹²	.160041x10 ¹³
Cottidae	.584279x10 ¹¹	0*	.612446x10 ⁷	.584341x10 ¹¹
Pacific cod	.138132x10 ¹³	.739439x10 ¹²	.610941x10 ¹¹	.218185x10 ¹³
Walleye pollock	.140297x10 ¹²	.736373x10 ¹²	.495125x10 ¹¹	.926183x10 ¹²
Thornyheads	0.	.347203x10 ¹²	.159276x10 ¹³	.193996x10 ¹³
Pacific ocean perch	.591767x10 ⁸	.451256x10 ¹⁴	.499724x10 ¹³	.501229x10 ¹⁴
Tanner crab	.954359x10 ¹¹	.458255x10 ¹²	.577467x10 ¹²	.113115x10 ¹³
King crab	0.	0.	.137800x10 ¹⁰	.137800x10 ¹⁰

Table 3---Variances of the biomass estimates for Prince William region for May-October 1961, Cr 052.

Species	Depth Zones (m)			Total
	0-100	101-200	201-400	
Elasmobranchs	.802363x10 ¹²	.165234x10 ¹³	.544770X1011	.250918x10 ¹³
Flatfishes	.723787x10 ¹²	.939985x10 ¹³	.691968x10¹²	.108156x10 ¹⁴
Roundfishes	.175517X1013	.110291x10 ¹³	.444983x10¹⁰	.286253x10 ¹³
Rockfishes	o.	.275920X1014	.267922x1013	.302713x10I4
Invertebrates	.634283x1010	.126447x1013	.987757x10¹²	.225857x10 ¹³
Skates				
Turbo t	.783312x10 ¹⁰	.738109x10 ¹³	.937473X1012	.832640x10 ¹³
Halibut	.319206x10 ¹²	.425383x10 ¹²	.432014x101°	.748910x10 ¹²
Flathead sole	.708116x10IO	.301509X1012	.334811x1011	.342072x1012
Dover sole	.729935x10 ⁸	.117688x10¹⁰	.432014x101°	.557002x10 ¹⁰
Rex sole	.212289x1010	.905496x1010	.415425x1010	.153321x1011
Rock sole	.598775x10¹¹	.826445x10 8	o.	.599601x1011
Sablefish	o.	.153172x10 ¹¹	.254456x1011	.407629x10¹¹
Cottidae	.437201x10 ⁸	.520217x10 ⁹	o.	.563937x10 ⁹
Pacific cod	.186863x10 ¹³	.150218x10 ¹²	.185766x101°	.202071x10 ¹³
Walleye pollock	.316305x10 9	.588516x1012	.140404x10¹¹	.602873x1012
Thornyheads	o.	.184031x10 ¹¹	.276489x10 ¹⁰	.211680X1011
Pacific ocean perch	O.	.274896x10 ¹⁴	.246356x10 ¹³	.299532x10 ¹⁴
Tanner crab	.129563xI0 ¹⁰	.996240x10 ¹²	.998774x10 ¹²	.199631x10 ¹³
King crab				

Table 4.--Variances of the biomass estimates **for the Kenai** region for May-October 1961, Cr 052.

Species	Depth Zones (m)			Total
	0-100	101-200	201-400	
Elasmobranchs	0.	● 973626x10 ¹³	0.	.973626x10 ¹³
Flatfishes	0.	● 108349x10 ¹⁵	0.	.108349x10 ¹⁵
Roundfishes	0*	.742632x10 ¹⁶	0.	.742632x10 ¹⁶
Rockfishes	0.	.357276x10 ¹⁵	0.	.357276x10 ¹⁵
Invertebrates	0.	.115678x10 ¹⁴	0.	.115678x10 ¹⁴
Skates	0.	.916046x10 ¹³	0.	.916048x10 ¹⁴
Turbot ,	0.	.319648x10 ¹⁴	0.	.319647x10 ¹⁴
Halibut ,	0.	.279657x10 ¹³	0.	.279657x10 ¹³
Flathead sole	0.	.243525x10 ¹⁴	0.	.243525x10 ¹⁴
Dover sole	0.	.350971x10 ¹⁰	0.	.350971x10 ¹⁰
Rex sole	0.	.511136x10 ¹⁰	0.	.511136x10 ¹⁰
Sablefish	0.	.102895x10 ¹²	0.	.102895x10 ¹²
Cottidae	0.	.149469x10 ¹²	0.	.149469x10 ¹²
Pacific cod	0*	● 778664x10 ¹⁶	0.	.778664x10 ¹⁶
Walleye pollock	0.	.872290x10 ¹⁴	0.	.872290x10 ¹⁴
Pacific ocean perch	0.	.357958x10 ¹⁵	0.	.35798x10 ¹⁵
Tanner crab	0.	● 115522x10 ¹⁴	0.	.115522x10 ¹⁴

Table 5.--Variances of the biomass estimates for the Kodiak region for May-October 1961, Cr 618.

Species	Depth Zones (m)			Total
	0-100	101-200	201-400	
Elasmobranchs	.853233x10 ¹¹	.1T4351X1012	.205532x10⁷	.199677x10 ¹²
Flatfishes	.185743x10 ¹⁵	.248489x10 ¹⁵	.751296x10 ¹³	.441745x10¹⁵
Roundfishes	.340374X1014	.289124x10¹⁴	.730083x10 ¹⁰	.629572x10 ¹⁴
Rockfishes	.901600X1012	.25400X1013	.127462x10¹¹	.345437X1013
Invertebrates	.438258x10 ¹⁵	.50060x10 ¹⁴	.194084x10 ¹³	.490204x10 ¹⁵
Skates	.854365x10¹¹	.110925x10 ¹²	.205532x107	.196364x10¹²
Turbo t	.122228x10 ¹³	.235860x10 ¹⁵	.694754x10 ¹²	.237777x10¹⁵
Halibut	.633176x10 ¹³	.118405x10 ¹³	.114827x10 ¹³	.866408x1013
Flathead sole	.190371x10¹³	.252926x10¹³	.761156x10¹²	.519449X1013
Dover sole	.266974x106	.109929x10¹¹	0.	.109931x10¹¹
Rex sole	.136124x1011	.201886x108	.416203x108	.338426x1011
Rock sole	.157706x10 ¹⁵	.332541x10¹²	.184979x10 ¹⁰	.158040x10 ¹⁵
Sablefish	.365488x109	.256568x10 ¹³	.328852x10 ⁸	.256608x1013
Cottidae	.609448x1013	.120554x1014	.174047x10¹⁰	.181516x1014
Pacific cod	.951930X1013	.280698x10¹³	.249146x1011	.123512x1014
Walleye pollock	.223089x1013	.304224x1013	.223824X108	.527316x1013
Thornyheads	0.	0.	0.	0.
Pacific ocean perch	.863220x1012	.254457x1013	.703384x1010	.341482x1013
Tanner crab	.593875x1013	.254789x1014	.139044X10¹³	.3280814x1014
King crab	.439450x10¹⁵	.240826x1014	.357398x10¹²	.463890x10 ¹⁵

Table 6.--Variances of the biomass estimates for the **Shelikof** region for May-October, 1961 Cruise 618.

Species	Depth Zones (m)			Total
	0-100	101-200	201-400	
Elasmobranchs	0.	.980368x10 ¹¹	.973404X1010	.107770X1012
Flatfishes	0.	.207888x10 ¹⁴	.386901x10 ¹³	.246578x10 ¹⁴
Roundfishes	0.	.337207x10 ¹³	.812938x10 ¹²	.418500x10 ¹³
Rockfishes	0.	.832804x1010	.219543x1012	.227871x1012
Invertebrates	0*	.641507x1013	.119758x1013	.761265x1013
Skates	0.	.980368x1011	.757673x108	.981126x10 ¹¹
Turbot	0.	.100807X1013	.341266x1011	.104220X1013
Halibut	0.	.597788x10 ¹¹	.454427x10 ⁹	.602322x10 ¹¹
Flathead sole	0.	.204082X1014	.766527x1010	.204159x1014
Dover sole	0.	.103812x10 ¹⁰	.387317x107	.104199X1010
Rex sole	0.	.190581x1010	.635169x106	.190644x1010
Rock sole	0.	.152788x10 ⁸	.716885x105	.151094X108
Sablefish	0.	.516209x10 ¹¹	.357904X108	.516567x10 ¹¹
Cottidae	0.	.122771x10 ¹²	.295559x109	.123066x1012
Pacific cod	0.	.183426x1013	.352077x1010	.183778x1013
Walleye pollock	0.	.112505x10 ¹³	.769104x10 ⁹	.112582x10 ¹³
Thornyheads				
Pacific ocean perch	0.	.787761x1010	.217440X1010	.100520x10 ¹¹
Tanner crab	0.	.554971X1013	.123555x10 ¹¹	.556206x10 ¹³
King crab	0.	.254353x10 ¹²	.336286x10 ⁹	.254689x10 ¹²
		0	0	

Table 7.--Variances of the biomass estimates for the **Chirikof** region for May-October 1961, **Cr** 618.

Species	Depth Zones (m)			Total
	0-100	101-200	201-400	
Elasmobranchs	.191753X10 ¹⁰	.404363x10¹¹	.141707X10 ¹³	.145942x10 ¹³
Flatfishes	.554530X10 ¹⁴	.247482x10 ¹⁴	.307677x10 ¹⁴	.110968x10 ¹⁵
Roundfishes	.851685x10 ¹³	.109182x10 ¹⁵	.171168x10¹³	.119410X10 ¹⁵
Rockfishes	.182101x10 ⁷	.217922x10 ¹⁵	.890534x10 ¹³	.226828X10 ¹⁵
Invertebrates	.598479x10 ¹⁶	.226720x10 ¹⁴	.149L39X10 ¹³	.600895x10 ¹⁶
Skates	.191753X10 ¹⁰	.407874x10 ¹¹	.142201x10 ¹³	.146472x10 ¹³
Turbot	.738327x10 ¹²	.531872x10 ¹³	.364037x10 ¹⁴	.424607x10 ¹⁴
Halibut	.118633x10¹⁴	.298503x10 ¹³	.105658x10 ¹²	.149540X10 ¹⁴
Flathead sole	.989245x10 ¹¹	.315174X10 ¹³	.872503x10 ¹²	.412316x10¹³
Dover sole	.408468x10 ⁷	.617563x10 ¹⁰	.220576x10 ¹²	.226755x10 ¹²
Rex sole	.164266x10 ¹⁰	.101957X10 ¹³	.103582x10 ¹³	.205703x10 ¹³
Rock sole	.342815x10 ¹⁴	.301705X10 ¹³	.396987x10 ¹¹	.373383x10 ¹⁴
Sablefish	.102117x10 ⁷	.191243x10 ¹²	.810374x10 ¹¹	.272281x10 ¹²
Cottidae	.709719X10 ¹³	.110334X10 ¹⁵	.824606x10 ¹¹	.117513X10¹⁵
Pacific cod	.606314x10 ¹²	.135927x10 ¹²	.206356x10 ¹¹	.762877x10¹²
Walleye pollock	.161436x10⁹	.706053X10 ¹³	.129718x10 ¹³	.835787x10 ¹³
Thornyheads	0.	0*	.126317x10 ¹³	.126317x10 ¹³
Pacific ocean perch	.196064x10 ⁷	.218035x10 ¹⁵	.601344x10 ¹³	.224049x10 ¹⁵
Tanner crab	.546354x10 ¹⁴	.135043X10 ¹⁴	.106097X10 ¹³	.692007X10 ¹⁴
King crab	.647729x10 ¹⁶	.320151x10 ¹³	.1L2326x10 ¹²	.648060x10 ¹⁶

Table 8.--Variances of the biomass estimates for the Shumagin region for May-October 1961, Cr 618.

Species	Depth Zones (m)			Total
	0-100	101-200	201-400	
Elasmobranchs	0.	.277124x10 ¹¹	.113566x10 ¹¹	.390691x10 ¹¹
Flatfishes	.178117x10 ¹⁴	.165222x10 ¹⁴	.137570x10 ¹⁵	.171904x10 ¹⁵
Roundfishes	.485914x10 ¹³	.151871x10 ¹⁴	.276322x10 ¹⁴	.476785x10 ¹⁴
Rockfishes	0.	.304454x10 ¹⁴	.321507x10 ¹⁴	.625962x10 ¹⁴
Invertebrates	.284507x10 ¹⁴	.144385x10 ¹⁴	.745583x10 ¹¹	.429638x10 ¹⁴
Skates	0.	.268042x10 ¹¹	.113566x10 ¹¹	.381609x10 ¹¹
Turbot	.334555x10 ¹²	.928011x10 ¹³	.137950x10 ¹⁵	.147565x10 ¹⁵
Halibut	.717522x10 ¹²	.184944x10 ¹²	.191952x10 ¹⁰	.904386x10 ¹²
Flathead sole	.537587x10 ¹²	.176692x10 ¹³	.308050x10 ¹³	.538501x10 ¹³
Dover sole	.600366x10 ⁹	.932577x10 ⁸	.290941x10 ¹⁰	.360303x10 ¹⁰
Rex sole	.502386x10 ⁸	.966891x10 ¹⁰	.172533x10 ¹¹	.269725x10 ¹¹
Rock sole	.399426x10 ¹³	.713983x10 ¹¹	0.	.406566x10 ¹³
Sablefish	.345811x10 ⁸	.148320x10 ¹¹	.196440x10 ¹⁴	.196589x10 ¹⁴
Cottidae	.351392x10 ¹³	.515840x10 ¹³	.695787x10 ¹⁰	.867928x10 ¹³
Pacific cod	.793900x10 ¹²	.581662x10 ¹¹	.422927x10 ¹²	.120499x10 ¹³
Walleye pollock	.473228x10 ¹⁰	.409146x10 ¹³	.199810x10 ¹³	.609429x10 ¹³
Thornyheads	0.	.465145x10 ⁹	.545732x10 ¹¹	.550383x10 ¹¹
Pacific ocean perch	0.	.302385x10 ¹⁴	.334149x10 ¹⁴	.636534x10 ¹⁴
Tanner crab	.119771x10 ¹⁴	.991640x10 ¹³	.754882x10 ¹¹	.219690x10 ¹⁴
King crab	.950756x10 ¹³	.313285x10 ¹³	0.	.126404x10 ¹⁴
Scallop	.240146x10 ¹⁰			.240146x10 ¹⁰

Table 9.--Variances of the biomass estimates for the Sanak region for May-October
1961, Cr 618.

Species	Depth Zones (m)			Total
	0-100	101-200	201-400	
Elasmobranchs	.154241x10 ¹⁰	.225950x10 ¹¹	.109903x10¹¹	.351278x10 ¹¹
Flatfishes	.890591x10¹³	.552864x10 ¹³	.360072x10 ¹²	.147946x10 ¹⁴
Roundfishes	.353098x10 ¹⁴	.176505x10 ¹⁴	.496258x10¹²	.534566x10 ¹⁴
Rockfishes	.286774x10 ⁹	.127938x10 ¹³	.449795x10¹³	.577763x10 ¹³
Invertebrates	.572513x10 ¹⁵	.177618x10 ¹⁴	0.	.590275x10 ¹⁵
Skates	.154241x10¹⁰	.226213x10¹¹	.109903x10 ¹¹	.351541x10 ¹¹
Turbot	.139849x10¹²	.411894x10 ¹²	.721256x10¹¹	.623869x10 ¹²
Halibut	.806370x10 ¹²	.283555x10 ¹²	.302940x10⁹	.109022x10 ¹³
Flathead sole	.189532x10 ¹²	.817655x10 ¹²	0.	.100718x10 ¹³
Dover sole	.438731x10 ⁹	.675307x10 ⁸	.298167x10 ⁸	.536078x10 ⁹
Rex sole	.512597x10 ¹⁰	.154919x10 ¹⁰	.343511x10 ¹²	.350186x10 ¹²
Rock sole	.548184x10 ¹³	.381601x10 ¹³	0.	.929786x10 ¹³
Sablefish	.109682x10 ⁷	.134017x10 ¹¹	.724608x10 ¹⁰	.206489x10¹¹
Cottidae	.268335x10 ¹⁴	.111036x10 ¹⁴	.610369x10 ¹⁰	.379432x10 ¹⁴
Pacific cod	.110381x10¹³	.286920x10 ¹³	.354248x10 ¹¹	.400844x10 ¹³
Walleye pollock	.686819x10 ¹¹	.141165x10 ¹³	.448861x10 ¹¹	.152522x10¹³
Thornyheads	0.	0.	.153816x10 ¹¹	.153816x10 ¹¹
Pacific ocean perch	.286774x10 ⁹	.127809x10 ¹³	.460891x10 ¹³	.588729x10 ¹³
Tanner crab	.350745x10 ¹⁴	.174116x10 ¹⁴	0.	.524862x10 ¹⁴
King crab	.554638x10 ¹⁵	.243505x10 ¹¹	0.	.554662x10 ¹⁵

Table 10. --Variance of the biomass estimates for the Kodiak region for September-
November 1961, Cr 619.

Species	Depth Zones (m)			Total
	0-100	101-200	201-400	
Elasmobranchs	.142397x10 ¹³	.472186x10 ¹⁰	.957384x10 ¹⁰	.143827x10 ¹³
Flatfish	.186883x10 ¹⁵	.964336x10 ¹⁴	.801065x10 ¹²	.284118x10 ¹⁵
Roundfish	.169634x10 ¹⁵	.106654x10 ¹⁵	.819259x10 ¹²	.277107x10 ¹⁵
Rockfish	.122080x10 ¹⁰	.298898x10 ¹³	.154869x10 ¹⁰	.299175x10 ¹³
Invertebrates	.322376x10 ¹⁵	.155850x10 ¹⁶	.158769x10 ¹⁴	.189676x10 ¹⁶
Skates	.142397x10 ¹³	.433657x10 ¹⁰	.957384x10 ¹⁰	.143788x10¹³
Turbot	.917099x10 ¹²	.397070x10 ¹⁴	.559562x10 ¹¹	.406800x10 ¹⁴
Halibut	.309415x10 ¹³	.475428x10 ¹³	.607341x10 ¹¹	.790916x10 ¹³
Flathead	.166883x10 ¹²	.170675x10 ¹⁴	.175846x10 ¹²	.174103x10 ¹⁴
Dover	.706121x10 ⁹	.467827x10 ⁹	.374583x10 ⁷	.117769x10¹⁰
Rex	.851216x10 ¹⁰	.200865x10 ¹³	.739916x10 ⁶	.201717x10 ¹³
Rock	1708515x10 ¹⁵	.151903x10 ¹³	.566499x10 ⁸	.172370x10 ¹⁵
Sablefish	o:	.137006x10 ¹²	.104050x10 ¹²	.241057x10 ¹²
Cottidae	.109530x10 ¹⁵	.374881x10 ¹⁴	.206668x10 ¹²	.147225x10 ¹⁵
Pacific cod	.513903x10 ¹³	.109223x10 ¹⁴	.266370x10 ¹⁰	.160640x10 ¹⁴
Walleye pollock	.764389x10 ¹⁰	.439062x10¹⁴	.145023x10⁹	.439140x10 ¹⁴
Thornyhead				
Pacific ocean perch	.125532x10¹⁰	.300074x10 ¹³	.240399x10 ¹⁰	.300440x10 ¹³
Dungeness crab	.837543x10 ¹³	.154577x10 ¹³	o.	.992121x10¹³
Tanner crab	.268759x10 ¹⁵	.140487x10 ¹⁵	.873046x10 ¹³	.417977x10 ¹⁵
King crab	.166531x10 ¹⁵	.159133x10 ¹⁶	.752922x10 ¹²	.175861x10 ¹⁶

Table 11.--Variances of the biomass estimates for the Shelikof region for September-November 1961, Cr 619.

Species	Depth Zones (m)			Total
	0-100	101-200	201-400	
Elasmobranchs	0.	.457885x10 ¹²	.193906x10 ¹¹	.477276x10 ¹²
Flatfish	0.	.201293x10 ¹⁴	.116848x10 ¹⁴	.318141x10 ¹⁴
Roundfish	0.	.198077x10 ¹³	.120425x10 ¹³	.318503x10 ¹³
Rockfish	0.	.160827x10 ¹¹	.486642x10 ¹²	.502725x10 ¹²
Invertebrates	0.	.299158x10 ¹³	.830563x10 ¹³	.112972x10 ¹⁴
Skates	0.	.884043x10 ¹¹	.189976x10 ¹¹	.107401x10 ¹²
Turbot	0.	.454572x10 ¹³	.424937x10 ¹³	.879510x10 ¹³
Halibut	0.	.672813x10 ¹²	.183782x10 ¹¹	.691191x10 ¹²
Flathead	0.	.606940x10 ¹³	.351662x10 ¹³	.958603x10 ¹³
Dover	0.	.150021x10 ⁹	.166529x10 ¹⁰	.181531x10 ¹⁰
Rex	0.	.283513x10 ⁹	.782450x10 ⁶	.284295x10 ⁹
Rock	0.	.121420x10 ⁹	.612320x10 ⁷	.127543x10 ⁹
Sablefish	0.	.134193x10 ¹²	.157899x10 ¹¹	.149983x10 ¹²
Cottidae	0.	.182669x10 ¹²	.756741x10 ¹⁰	.190236x10 ¹²
Pacific cod	0.	.286137x10 ¹¹	.176379x10 ¹²	.204992x10 ¹²
Walleye pollock	0.	.927527x10 ¹²	.776923x10 ¹²	.170445x10 ¹³
Thornyhead				
Pacific ocean perch	0.	.121966x10 ¹¹	.486036x10 ¹²	.498232x10 ¹²
Dungeness crab	0.	.300023x10 ¹²	0.	.300023x10 ¹²
Tanner crab	0.	.295854x10 ¹³	.930997x10 ¹²	.388954x10 ¹³
King' crab	0.	.164250x10 ¹²	.503192x10 ¹³	.519617x10 ¹³

Table 12.--Variances of the biomass estimates for the **Chirikof** region for May-October 1961, Cr 619.

Species	Depth Zones (m)			Total
	0-100	101-200	201-400	
Elasmobranchs	.260173x10 ¹²	.333889x10 ¹⁰	.904359x10 ¹¹	.353948x10 ¹²
Flatfishes	.761557x10 ¹⁴	.383442x10 ¹⁵	.516942x10 ¹⁴	.511292x10 ¹⁵
Roundfishes	.158822x10 ¹⁴	.803867x10 ¹⁴	.745720x10 ¹⁴	.170840x10 ¹⁵
Rockfishes	0.	.314818x10 ¹⁴	.146948x10 ¹⁴	.461767x10 ¹⁴
Invertebrates	.668480x10 ¹⁶	.121439x10 ¹⁶	.796366x10 ¹⁴	.797884x10 ¹⁶
Skates	.176719x10¹²	.333889x10 ¹⁰	.904359x10¹¹	.270494x10 ¹²
Turbo t	.876166x10 ¹²	.181794x10 ¹⁵	.268424x10 ¹⁴	.209513x10 ¹⁵
Halibut	.755218x10 ¹⁴	.184229x10¹³	.443744x10¹²	.778078x10 ¹⁴
Flathead Sole	.126877x10 ¹³	.658588x10¹⁴	.601849x10 ¹³	.731461x10 ¹⁴
Dover sole	0.	.455551x10¹¹	.342993x10 ¹²	.388548x10 ¹²
Rex sole	.480150x10 ⁹	.138778x10 ¹³	.441850x10 ¹²	.183011x10 ¹³
Rock sole	.373660x10 ¹³	.357487x10 ¹⁴	.556286x10⁷	.394853x10¹⁴
Sablefish	.175203x10 ¹¹	.105187x10 ¹³	.436159x10 ¹²	.150555x10 ¹³
Cottidae	.160787x10 ¹⁴	.167763x10¹⁴	.113645x10 ¹¹	.328664x10 ¹⁴
Pacific cod	.682833x10 ⁹	.250143x10 ¹³	.852199x10 ¹¹	.258733x10 ¹³
Walleye pollock	.603809x10 ¹¹	.815023x10 ¹⁴	.707497x10 ¹⁴	.152312x10 ¹⁵
Thornyheads	0.	0.	.129883x10 ¹²	.129883x10¹²
Pacific ocean perch	0.	.315046x10 ¹⁴	.126493x10 ¹⁴	.441540x10¹⁴
Dungeness crab	.532614x10 ¹⁰	.325408x10 ¹²	0.	.330734x10 ¹²
Tanner crab	.835222x10 ¹⁴	.333873x10 ¹⁵	.130612x10 ¹⁴	.430457x10 ¹⁵
King crab	.653028x10¹⁶	.102460x10 ¹⁶	.413749x10 ¹⁴	.759626x10 ¹⁶

Table 13.--**Varinaces** of the biomass estimates for the **Shumagin** region for September-November 1961, Cr 619.

Species	Depth Zones (m)			Total
	0-100	101-200	201-400	
Elasmobranchs	0.	.273902x10 ¹¹	.826448x10 ⁸	.274728x10 ¹¹
Flatfish	.134995x10 ¹⁴	.221405x10 ¹⁴	.251028x10 ¹³	.381503x10 ¹⁴
Roundfish	.132063x10 ¹³	.255286x10 ¹⁴	.547212x10 ¹³	.323214x10 ¹⁴
Rockfish	.165476x10 ⁷	.649259x10 ¹¹	.405190x10 ¹⁴	.405840x10 ¹⁴
Invertebrates	.152639x10 ¹⁵	.457400x10 ¹⁴	.248565x10 ¹¹	.198404x10 ¹⁵
Skates	0.	.273902x10 ¹¹	.826448x10 ⁸	.274728x10 ¹¹
Turbot	.111490x10 ¹²	.121949x10 ¹⁴	.139693x10 ¹³	.137033x10 ¹⁴
Halibut	.468917x10 ¹³	.318108x10 ¹²	.587933x10 ¹⁰	.501316x10 ¹³
Flathead	.156480x10 ⁸	.177881x10 ¹³	.314918x10 ¹²	.209375x10 ¹³
Dover	.184650x10 ⁸	.571932x10 ⁸	.435118x10 ⁸	.119170x10 ⁹
Rex	.212869x10 ⁸	.259980x10 ¹⁰	.116087x10 ¹⁰	.378196x10 ¹⁰
Rock	.117238x10 ¹⁴	.115085x10 ¹²	.681408x10 ⁸	.118399x10 ¹⁴
Sablefish	0.	.195032x10 ¹¹	.485092x10 ¹¹	.680124x10 ¹¹
Cottidae	.129466x10 ¹²	.132507x10 ¹⁴	.237475x10 ¹¹	.145691x10 ¹⁴
Pacific cod	.933051x10 ¹⁰	.210540x10 ¹²	.195209x10 ¹³	.217196x10 ¹³
Walleye pollock	.661904x10 ⁷	.975512x10 ¹³	.820188x10 ¹³	.179570x10 ¹⁴
Thornyhead	0.	.312478x10 ¹⁰	0.	.312478x10 ¹⁰
Pacific ocean perch	.165476x10 ⁷	.355050x10 ¹⁰	.405190x10 ¹⁴	.405226x10 ¹⁴
Dungeness crab	.132557x10 ¹⁴	.741987x10 ¹¹	0.	.133299x10 ¹⁴
Tanner crab	.114114x10 ¹⁵	.342685x10 ¹⁴	.257314x10 ¹¹	.148408x10 ¹⁵
King crab	.264761x10 ¹²	.275004x10 ¹³	0.	.301480x10 ¹³

Table 14. --Variances of the biomass estimates for the **Sanak** region for September-November 1961, Cr 619.

Species	Depth Zones (m)			Total
	0-100	101-200	201-400	
Elasmobranchs	.188769x10 ¹¹	.372751x10¹¹	0.	.561521x10 ¹¹
Flatfish	.392575x10 ¹⁴	.114657x10 ¹⁴	0.	.507232x10 ¹⁴
Roundfish	.102598x10 ¹⁵	.144943x10 ¹⁴	0.	.117092x10 ¹⁵
Rockfish	.202591x10⁸	.156035x10 ¹²	0.	.156044x10 ¹²
Invertebrates	.915436x10 ¹⁵	.711604x10 ¹⁵	0.	.162704x10 ¹⁶
Skates	.184571x10 ¹¹	.372751x10 ¹¹	0.	.557323x10¹¹
Turbot	.225402x10 ¹³	.303822x10 ¹³	0.	.529225x10 ¹³
Halibut	.688612x10¹²	.734582x10 ¹¹	0.	.762071x10 ¹²
Flathead	.179334x10 ¹²	.188886x10 ¹³	0.	.206820x10¹³
Dover	0.	.342461x10¹¹	0.	.342460x10 ¹¹
Rex	.180746x10 ¹¹	.144907x10 ¹²	0.	.162971x10 ¹²
Rock	.231546x10 ¹⁴	.388017x10 ¹³	0.	.270348x10 ¹⁴
Sablefish	.342218x10¹⁰	.104934x10 ¹⁰	0.	.446996x10 ¹⁰
Cottidae	.658412x10 ¹⁴	.103284x10 ¹⁴	0.	.761697x10 ¹⁴
Pacific cod	.495430x10 ¹³	.230510x10 ¹³	0.	.725941x10 ¹³
Walleye pollock	.147462x10 ¹¹	.828684x10 ¹¹	0.	.976130x10 ¹¹
Thornyhead	0.	.772784x10 ¹¹	0.	.772784x10 ¹¹
Pacific ocean perch	.667359x10 ⁷	.356602x10 ¹¹	0.	.356560x10¹¹
Dungeness crab	.416458x10 ¹³	.145111x10 ¹¹	0.	.417909x10 ¹³
Tanner crab	.868630x10¹⁵	.632831x10¹⁵	0.	.150146x10 ¹⁶
King crab	.142755x10 ¹⁴	.177240x10 ¹⁴	0.	.319995x10 ¹⁴

Table 16. --Variances of the biomass estimates for the **Yakutat** region for June-August 1962, Cr 628.

Species	Depth Zones (ID)			Total
	0-100	101-200	201-400	
Elasmobranchs	.115873x10 ¹²	.334935x10 ¹²	.870225x10 ¹¹	.537831x10 ¹²
Flatfish	.131605x10 ¹⁴	.233193x10 ¹⁴	.233193x10 ¹⁴	.898771x10 ¹⁴
Roundfish	.127682x10 ¹³	.404385x10 ¹²	.197217x10 ¹³	.365338x10 ¹³
Rockfish	0.	.613854x10 ¹⁴	.241949x10 ¹³	.638049x10 ¹⁴
Invertebrates	.101669x10 ¹⁴	.946594x10 ¹³	.135273x10 ¹³	.209856x10 ¹³
Skates	.240915x10 ¹¹	.302509x10 ¹²	.925100x10 ¹¹	.419111x10 ¹²
Turbot	.359974x10 ¹³	.350571x10 ¹⁴	.939179x10 ¹³	.480486x10 ¹⁴
Halibut	.181133x10 ¹²	.266450x10 ¹²	.111618x10 ¹⁰	.448699x10 ¹²
Flathead	.220415x10 ¹²	.366898x10 ¹³	.168939x10 ¹³	.557879x10 ¹³
Dover	.139205x10 ¹²	.539367x10 ¹¹	.989892x10 ¹²	.104384x10 ¹³
Rex	.511467x10 ¹¹	.395837x10 ¹¹	.597012x10 ¹²	.687743x10 ¹²
Rock	.780647x10 ⁹	.525845x10 ⁸	0.	.833232x10 ⁹
Sablefish	.141899x10 ¹⁰	.616723x10 ¹¹	.362338x10 ¹¹	.993252x10 ¹¹
Cottidae	0.	.191690x10 ¹⁰	.430894x10 ¹	.622584x10 ¹⁰
Pacific cod	.698289x10 ¹¹	.173109x10 ¹¹	.275635x10 ¹¹	.114703x10 ¹²
Walleye pollock	.691862x10 ¹²	.161336x10 ¹²	.127485x10 ¹³	.212805x10 ¹³
Thornyhead	0.	.883358x10 ¹⁰	.665143x10 ¹²	.673977x10 ¹²
Pacific ocean perch	0.	.614729x10 ¹⁴	.329419x10 ¹³	.647671x10 ¹⁴
Tanner crab	.214015x10 ¹²	.500971x10 ¹²	.135273x10 ¹³	.206771x10 ¹³
Scallop	.122593x10 ¹⁴	.757709x10 ¹³	0.	.198364x10 ¹⁴

Table 17.--**Varinaces** of the biomass estimates for the Prince William region for June-August 1962, Cr 628.

Species	Depth Zones (m)			Total
	0-100	101-200	201-400	
Elasmobranchs	.194404x10 ¹³	.289738x10 ¹²	.148075x10 ¹¹	.224858x10 ¹³
Flatfish	.136759x10 ¹⁴	.741606x10 ¹⁴	.430371x10 ¹³	.921403x10 ¹⁴
Roundfish	.293107x10 ¹²	.482412x10 ¹³	.122206x10 ¹²	.523943x10 ¹³
Rockfish	.121387x10¹⁰	.929667x10 ¹³	.416388x10 ¹³	.134617x10 ¹⁴
Invertebrates	.313617x10 ¹⁴	.114084x10 ¹³	.125407x10 ¹²	.326279x10 ¹⁴
Skates	.162987x10 ¹³	.282015x10 ¹²	.118333x10 ¹¹	.192372x10 ¹³
Turbot	.250197x10 ¹³	.313702x10 ¹⁴	.285135x10¹³	.367236x10 ¹⁴
Halibut	.394024x10 ¹²	.204704x10 ¹²	.225488x10 ⁹	.598955x10 ¹²
Flathead	.452828x10 ¹²	.131737x10 ¹⁴	.394659x10 ¹²	.140212x10 ¹⁴
Dover	.163366x10 ¹⁰	.135199x10¹²	.900943x10 ¹¹	.226927x10 ¹²
Rex	.101754x10 ¹²	.729798x10 ¹¹	.625899x10 ¹¹	.237324x10 ¹²
Rock	.520156x10 ¹¹	.163432x10 ⁷	0.	.520172x10 ¹¹
Sablefish	.114868x10¹¹	.498541x10¹¹	.184301x10 ¹¹	.797712x10 ¹¹
Cottidae	.189963x10 ⁹	.344263x10 ¹¹	.193461x10 ¹⁰	.365509x10 ¹¹
Pacific cod	.353767x10¹¹	.455175x10 ¹¹	.104680x10 ¹¹	.913624x10 ¹¹
Walleye pollock	.717889x10 ¹⁰	.418807x10 ¹³	.139031x10¹²	.433428x10 ¹³
Thornyhead ^{o*}		.344861x10 ¹¹	.725416x10 ¹¹	.107027x10 ¹²
Pacific ocean perch	.122051x10¹⁰	.892822x10 ¹³	.398842x10 ¹³	.129178x10 ¹⁴
Tanner crab	.219095x10 ¹²	.104395x10 ¹³	.125470x10¹²	.138851x10¹³
Scallop	.993523x10 ⁸	.136548x10 ¹²	0.	.136648x10 ¹²

Table 19. --Varinaces of the biomass estimates for the Fairweather region for May-October 1962, Cr 629.

Species	Depth Zones (m)			Total
	0-100	101-200	201-400	
Elasmobranchs	.612021x10 ¹²	.113970x10 ¹³	.163204x10 ¹³	.338376x10 ¹³
Flatfish	.242970x10 ¹⁴	.156153x10¹⁵	.623247x10 ¹³	.186682x10¹⁵
Roundfish	.107701x10 ¹¹	.831458x10 ¹³	.241084x10 ¹³	.107361x10¹⁴
Rockfish	o.	.408196x10 ¹²	.396999x10 ¹³	.437818x10 ¹³
Invertebrates	.176630x10 ¹³	.58703x10 ¹³	.133228x10 ¹²	.777036x10 ¹³
Skates	.472105x10¹¹	.994228x10 ¹²	.661511x10 ¹²	.170294x10 ¹³
Turbot	.289699x10 ¹²	.781212x10 ¹⁴	.125056x10 ¹²	.785359x10 ¹⁴
Halibut	.947467x10 ¹¹	.129230x10 ¹³	o.	.138704x10¹³
Flathead	.290806x10 ¹¹	.627567x10 ¹³	.446734x10 ¹³	.107720x10¹⁴
Dover	.423511x10 ¹⁰	.932059x10 ¹²	.331260x10 ¹²	.126755x10¹³
Rex	.383866x10 ¹²	.245166x10 ¹³	.305477x10 ¹¹	.286607x10¹³
Rock	.207333x10 ⁹	.342350x10 ⁹	o.	.549684x10 ⁹
Sablefish	.147662x10 ⁹	.576687x10 ¹³	.447613x10 ¹²	.621463x10 ¹³
Cottidae	.742099x10 ⁷	.108355x10 ¹⁰	o.	.109097x10 ¹⁰
Pacific cod	.667889x10 ¹⁰	.799801x10¹¹	o.	.866590x10¹¹
Walleye pollock	.250799x10 ⁹	.288982x10 ¹³	.358953x10 ¹²	.324903x10 ¹³
Thornyhead	o.	.173626x10 ¹²	.370737x10 ¹²	.544364x10 ¹²
Pacific ocean perch	o.	.265708x10 ¹²	.495777x10 ¹³	.522347x10 ¹³
Tanner crab	.514926x10 ⁹	.553613x10 ¹³	.133228x10 ¹²	.566988x10 ¹³
Scallop	.140540x10 ¹³	.116402x10 ¹³	o.	.256942x10 ¹³

Table 20. --Varinaces of the biomass estimates for the Yakutat region for May-October 1962, Cr 629.

Species	Depth Zones (m)			Total
	0-100	101-200	201-400	
Elasmobranchs	.599104X10 ¹²	.114166x10 ¹³	.468772x10 ¹²	.220953x10¹³
Flatfish	.125631x10 ¹²	.125631x10 ¹⁴	.515395x10¹¹	.133939X10 ¹⁴
Roundfish	.142001x10 ¹¹	.184630x10 ¹³	.161842x10 ¹²	.202234x10 ¹³
Rockfish	.394165x10⁹	.628028X10 ¹³	.234546x10 ¹³	.862614x10 ¹³
Invertebrates	.680391x10 ¹¹	.151146x10 ¹³	.401375X10 ¹²	.198088x10¹²
Skates	.863282x10 ¹²	.994448x10 ¹²	.434645x10 ¹²	.229237x10¹³
Turbo t	.134714X10 ¹¹	.383561x10 ¹³	.221859x10 ¹²	.407094X10 ¹³
Halibut	.419986x10 ¹²	.560669x10 ¹²	.361453x10 ¹²	.638813x10 ¹³
Flathead	.798310X10 ⁸	.965004x10 ¹¹	.452556x10 ¹¹	.141833x10¹²
Dover	0.	0.	.172689x10 ⁹	.172689x10⁹
Rex	.536364x10 ¹⁰	.187235x10 ¹¹	180516x10 ¹¹	.421388x10 ¹¹
Sablefish	0.	.994434X10 ⁹	0:	.994434X10 ⁹
Cottidae	.162156x10 ⁸	.257740X10 ¹¹	0.	.257902x10 ¹¹
Pacific cod	.179619x10 ¹¹	.139769x10¹³	.420777x10¹¹	.145773X10¹²
Walleye pollock O.		.805532x10¹¹	.134960X10 ¹²	.215513x10¹²
Thornyhead	.611206x10 ⁸	.284509x10 ¹³	.328735x10 ¹²	.137389x10 ¹³
Pacific ocean perch	.210803x10 ⁹	.809638x10¹¹	.269684x10 ¹³	.277801x10 ¹³
Dungeness crab	.916427x10 ¹⁰	0.	0.	.916427x10 ¹⁰
Tanner crab	.587512x10 ⁹	.245272x10 ¹²	.387470X10 ¹²	.633329x10 ¹²
Scallop	.779600x10 ¹¹	.997811x10 ¹⁰	.137800X10 ¹⁰	.891160x10 ¹¹

Table 21---Variances of the biomass estimates for the Prince William region for May-October 1962, Cr 629.

Species	Depth Zones (m)			Total
	0-100	101-200	201-400	
Elasmobranchs	.116894x10 ¹⁴	.388744x10 ¹²	.111560x10 ¹²	.121897x10 ¹⁴
Flatfish	.658560x10¹³	.611509x10 ¹³	.350976x10¹³	.162104x10¹⁴
Roundfish	.132960x10 ¹¹	.390956x10 ¹²	.807056x10 ¹³	.847481x10 ¹³
Rockfish	.597102x10 ¹⁰	.561879x10 ¹²	.244236x10 ¹²	.812086x10 ¹²
Invertebrates	.951309x10 ¹³	.154593x10¹³	.138168x10 ¹²	.111971x10 ¹⁴
Skates	.978347x10 ¹³	.293034x10¹²	.569374x10¹¹	.101334x10¹⁴
Turbot	.243570x10 ¹³	.215814x10 ¹³	.178611x10 ¹³	.637997x10 ¹³
Halibut	.279191x10 ¹²	.728913x10 ¹¹	.130335x10¹¹	.365116x10 ¹²
Flathead	.222688x10 ¹²	.140691x10¹²	.120916x10 ¹²	.175051x10 ¹²
Dover	.128071x10 ⁹	.126897x10¹⁰	.204457x10 ¹²	.205854x10¹²
Rex	.805824x10 ¹¹	.152045x10 ¹¹	.151304x10 ¹¹	.110917x10 ¹²
Sablefish	.119809x10 ¹¹	.447797x10 ¹⁰	.968006x10 ¹¹	.113259x10 ¹²
Cottidae	.619215x10 ⁹	.144026x10¹¹	.736245x10 ¹⁰	.223843x10¹¹
Pacific cod	.743950x10 ¹⁰	.236157x10 ¹²	.264498x10¹¹	.246241x10 ¹²
Walleye pollock	.877246x10 ⁹	.110871x10 ¹²	.584023x10 ¹³	.595198x10 ¹³
Thornyheads	o.	.120420x10 ¹⁰	.158254x10¹¹	.170296x10¹¹
Pacific ocean perch	.597102x10 ¹⁰	.519510x10 ¹²	.110626x10 ¹²	.636108x10¹²
Dungeness crab	.676940x10 ¹³	o.	o.	.676940x10 ¹³
Tanner crab	.245773x10 ¹³	.155866x10 ¹³	.135517x10 ¹²	.415191x10 ¹³
Scallop	.639491x10⁹	.652066x10 ¹¹	o.	.658461x10 ¹¹

Table 22. --Variances of the biomass estimates for the Fairweather region for April-October 1976, Cr 762.

Species	Depth Zones (m)			Total
	0-100	101-200	201-400	
Elasmobranchs				
Flatfishes	.185809x10 ¹⁴	.157430X1014	.299974x101 ⁴	.106521x10 ¹⁵
Roundfishes	.145938x10 ¹²	.105203x10 ¹³	.391656x10 ¹²	.158962x1013
Rockfishes	.149777x10 ⁹	.545059X1012	.542085x10 ¹²	.108729x1013
Invertebrates	.146832x1013	.347985x1015	.272176x1011	.349481x1015
Skates	.676770X1011	.197853x1013	.140587x1012	.218679x1013
Turbot	.332172x1011	.993813x1013	.717802x1013	.171493X1014
Halibut	.102336x1012	.246800X1012	0.	.349137x1012
Flathead sole	.199703X109	.260944x1014	.177499X1014	.438446x1014
Dover sole	.599108x107	.817498x109	.428314x101 ²	.429137x10 ¹²
Rex sole	.393459X1010	.983563x10 ¹²	.446347x10 ¹²	.143384x10 ¹³
Rock sole	.576919x109	.104497X1010	0.	.162189x1010
Sablefish	0.	.104497X1010	.743601x109	.178857x1010
Cottidae	0.	● 537842x1010	.390855x10 ¹¹	.444639x1011
Pacific cod	.128209x10 ¹²	.211054x1012	0.	.339263x10 ¹²
Walleye pollock	.405619x109	.953059X1011	.281306x1012	.377017x1012
Smelt	.416047x109	.576057x10 ¹²	.562348x10 ¹⁰	.582097x10 ¹²
Thornyhead	0.	.128610X1012	.582983x1012	.711593x1012
Pacific ocean perch	0.	.212599x1012	0.	.212599x1012
Tanner crab	.909757X109	.447624x1012	0.	.448534x1012
King Crab	0.	.307948x1011	0.	.307948x1011
Scallop	.156092x1013	.340079X109	0.	.156126x1013

Table 23.--Variances of the biomass estimates for the Yakutat region for April-October 1975, Cr 751.

Species	Depth Zones (m)			Total
	0-100	101-200	201-400	
Elasmobranchs	.561359x10 ¹²	.190138x10 ¹²	.172185x10 ¹²	.913684x10 ¹²
Flatfishes	.207721x10 ¹⁵	.398728x10 ¹⁴	.328370x10 ¹⁴	.280430x10 ¹⁵
Roundfishes	.486011x10 ¹³	.339674x10 ¹³	.946315x10 ¹²	.920318x10 ¹³
Rockfishes	.201795x10 ⁸	.263311x10 ¹²	.365432x10 ¹²	.628764x10 ¹²
Invertebrates	.989152x10 ¹²	.120873x10 ¹³	.105632x10 ¹⁴	.127611x10 ¹⁴
Skates	0.	0.	0.	0.
Turbot	.10257x10 ¹³	.205291x10 ¹⁴	.870712x10 ¹³	.302619x10 ¹⁴
Halibut	.321934x10 ¹²	.294272x10 ¹²	.203578x10 ⁹	.616410x10 ¹²
Flathead sole	.288359x10 ¹²	.407353x10 ¹³	.372564x10 ⁹	.436226x10 ¹³
Dover sole	.112132x10 ¹⁰	.970744x10 ¹⁰	.825569x10 ¹³	.826652x10 ¹³
Rex sole	.141153x10 ¹²	.683446x10 ¹¹	.171484x10 ¹³	.192434x10 ¹³
Rock sole	.883190x10 ¹⁰	0.	0.	.883190x10 ¹⁰
Sablefish	.339286x10 ⁹	.342228x10 ¹⁰	.103675x10 ¹³	.104051x10 ¹³
Cottidae	.958701x10 ⁸	.288144x10 ¹⁰	.919050x10 ¹⁰	.121678x10 ¹¹
Pacific cod	.106054x10 ¹³	.114916x10 ¹³	.126322x10 ¹⁰	.221097x10 ¹³
Walleye pollock	.583911x10 ¹³	.127594x10 ¹³	.939732x10 ⁹	.711600x10 ¹³
Smelt	.448236x10 ⁹	.118766x10 ¹¹	.445247x10 ⁹	.127701x10 ¹¹
Thornyhead	.151115x10 ⁷	.568935x10 ¹¹	.338163x10 ¹²	.395059x10 ¹²
Pacific ocean perch	.192748x10 ⁸	.451822x10 ¹¹	.537817x10 ¹¹	.989833x10 ¹¹
Tanner crab	.376603x10 ¹²	.260483x10 ¹¹	.592752x10 ¹⁰	.408579x10 ¹²
King crab	0.	0.	0.	0.
Scallop	.104483x10 ¹²	.728068x10 ¹¹	.168246x10 ⁷	.177292x10 ¹²

Table 24.--Variances of the biomass estimates for the Prince William region for **April-October** 1975, Cr 751.

Species	Depth Zones (m)			Total
	0-100	101-200	201-400	
Elasmobranchs	.257134x10 ¹³	.147940x10 ¹²	.442941x10 ¹¹	.276357x10 ¹³
Flatfishes	.598772x10 ¹³	.322910x10 ¹³	.241521x10 ¹³	.116320x10 ¹⁴
Roundfishes	.126374x10 ¹⁴	.341623x10 ¹⁴	.300159x10 ¹³	.488013x10 ¹⁴
Rockfishes	.870550x10 ¹¹	.857077x10 ¹²	.481841x10 ¹²	.142597x10 ¹³
Invertebrates	.216665x10 ¹⁴	.623150x10 ¹³	.616628x10 ¹³	.340643x10 ¹⁴
Skates	.257246x10 ¹³	.144033x10 ¹²	.421121x10 ¹¹	.275860x10 ¹³
Turbot	.154851x10 ¹³	.128420x10 ¹³	.237860x10 ¹²	.307057x10 ¹³
Halibut	.290441x10 ¹²	.144620x10 ¹²	0.	.435061x10 ¹²
Flathead sole	.107711x10 ¹³	.464005x10 ¹³	.330475x10 ¹³	.484587x10 ¹³
Dover sole	.744365x10 ¹⁰	.139773x10 ¹²	.533023x10 ¹²	.680241x10 ¹²
Rex sole	.522793x10 ¹¹	.950094x10 ¹¹	.284215x10 ¹²	.431504x10 ¹²
Rock sole	.389153x10 ¹¹	.256887x10 ⁸	0.	.389410x10 ¹¹
Sablefish	.541492x10 ¹⁰	.464443x10 ¹⁰	.700793x10 ¹¹	.801387x10 ¹¹
Cottidae	.222495x10 ¹¹	.571009x10 ¹⁰	.355506x10 ¹¹	.635102x10 ¹¹
Pacific cod	.275425x10 ¹²	.495514x10 ¹²	● 147043x10 ¹²	.917983x10 ¹²
Walleye pollock	.115916x10 ¹⁴	.320574x10 ¹⁴	.254875x10 ¹³	.461979x10 ¹⁴
Smelt	.212185x10 ¹¹	.585966x10 ⁹	.238715x10 ¹²	.260519x10 ¹²
Thornyhead	.868187x10 ¹¹	.597248x10 ¹¹	.386586x10 ¹²	.533130x10 ¹²
pacific ocean perch	0.	.748742x10 ¹²	.201250x10 ¹²	.750755x10 ¹²
Tanner crab	.856260x10 ¹³	.561713x10 ¹³	.653283x10 ¹³	.207125x10 ¹⁴
Scallop	.289677x10 ¹¹	.276885x10 ⁹	.164062x10 ⁸	.292610x10 ¹⁰

Table 25. --Variances of the biomass estimates for the Kenai region for April - October, 1976 Cruise 762.

Species	Depth Zones (m)			Total
	0-100	101-200	201-400	
Elasmobranchs	o.	.950106X1010	.149052x10¹¹	.244063x1011
Flatfishes	o.	.273772x1015	.100768x10¹⁴	.283849x1015
Roundfishes	o.	.311069x1015	.155790X1014	.326648x1015
Rockfishes	0 ₀	.847467x1012	.320720X1011	.879539x1012
Invertebrates	o.	.568068x1014	.162612X1013	.584329x1014
Skates	o.	.940983x1010	.140255x1011	.234353x10¹¹
Turbot	o.	.928049x1014	.374973X1013	.965547x1014
Halibut	o.	.144763x10¹³	.181551x1013	.326314x1013
Flathead sole	o.	.150026x10¹⁴	.126628x10¹³	.162725x10 ¹⁴
Dover sole	o.	.212255x1014	.633208x10¹¹	.212888X1014
Rex sole	o.	.104686x10¹³	.492619x1011	.109613x1013
Rock sole	o.	.310661x10⁹	o.	.310661X109
Sablefish	o.	.102906x1012	.183488x10 ¹²	.286394x1012
Cottidae	o.	.234735x10 ¹²	.332087x10¹⁰	.238056x1012
Pacific cod	o.	.26641x1013	.150675x1013	.417116x1013
Walleye pollock	O.	.282708x1015	.822004X1013	.290928x1015
Sme 1 t	o.	.333247x10¹¹	.556254x109	.338809x10¹¹
Thomyhead	o.	.192434x10¹¹	.357948X1011	.550382x10¹¹
Pacific ocean perch	O.	.178902x10¹²	o.	.178902x10 ¹²
Tanner crab	o.	.463897x1012	.807488x10 ¹¹	.544645x10¹²
King crab	o.	.180890X1013	.137376x1013	.318267x1013

Table 26.--variances of the biomass estimates for the Kodiak region for April-October 1973, Cr 734.

Species	Depth Zones (m)			Total
	0-100	101-200	201-400	
Elasmobranchs	0.	.135880x10 ¹¹	.34140x10 ⁸	.136222x10 ¹¹
Flatfishes	.208195x10 ¹⁵	.860323x10 ¹⁴	.491708x10 ¹⁴	.343398x10 ¹⁵
Roundfishes	.107199x10¹⁶	.168042x10 ¹⁶	.231432x10 ¹⁵	.298384x10 ¹⁶
Rockfishes	.468853x10 ⁹	.361801x10¹¹	.111764x10 ¹⁴	.112130x10 ¹⁴
Invertebrates	.290709x10 ¹⁵	.194703x10 ¹⁵	.956232x10 ¹³	.494974x10¹⁵
Skates	0.	.135880x10¹¹	.341401x10 ⁸	.136222x10 ¹¹
Turbo t	.250352x10 ¹²	.358737x10 ¹³	.381263x10 ¹³	.765036x10 ¹³
Halibut	.643642x10 ¹³	.173811x10¹²	.425940x10 ¹¹	.665282x10 ¹³
Flathead sole	.194864x10 ¹³	.179000x10¹⁴	.182089x10 ¹³	.216696x10 ¹⁴
Dover sole	.468853x10 ⁷	.573317x10 ¹³	.372869x10 ¹⁴	.430201x10 ¹⁴
Rex sole	.382584x10¹¹	.171761x10 ¹⁴	.137376x10 ¹⁴	.154935x10 ¹⁴
Rock sole	.189442x10¹⁵	.362160x10 ¹³	.729535x10 ¹³	.200359x10 ¹⁵
Sablefish	0.	.166551x10 ¹²	.354764x10 ¹²	.521315x10 ¹²
Cottidae	.422254x10 ¹⁴	.212313x10 ¹³	.152126x10 ¹²	.445006x10 ¹⁴
Pacific cod	.523537x10 ¹⁵	.435510x10 ¹⁴	.572535x10¹¹	.567145x10 ¹⁵
Walleye pollock	.456427x10¹⁴	.144797x10 ¹⁶	.244770x10 ¹⁵	.173838x10 ¹⁶
Smelt	0.	.578708x10 ⁸	0.	.578708x10 ⁸
Thornyhead	0.	0.	.342208x10 ¹²	.342208x10 ¹²
Pacific ocean perch	.468853x10 ⁹	.369752x10 ¹¹	.130730x10¹²	.168174x10 ¹²
Tanner crab	.977559x10 ¹²	.186201x10 ¹⁴	.848482x10 ¹³	.280825x10 ¹⁴
King crab	.823540x10 ¹³	.122720x10 ¹⁵	.665433x10 ¹¹	.131022x10 ¹⁵
Scallop	.144461x10 ¹³	0.	0.	.144461x10 ¹³

Table 27.--Variances of the biomass estimates for the Shelikof region for April-October 1973, Cr 733.

Species	Depth Zones (m)			Total
	0-100	101-200	201-400	
Elasmobranchs	.614624x108	.423051x109	.408186x1011	.413031X1011
Flatfishes	.546531x1011	.478030X1013	.475071X1013	.958567x1013
Roundfishes	.211419x1011	.165747x1014	.844474x1013	.250406X1014
Rockfishes	o.	.121944x1010	.656991x101.0	.778936x1010
Invertebrates	.914371X1011	.248319x1013	.212474x1014	.238220X1014
Skates	o.	.423051x109	.408186x1011	.412416x1011
Turbot	.345726x106	.337415X1011	.131337X1012	.165078x1012
Halibut	.266478x1011	.539432x1012	.230154x1013	.286762x1013
Flathead sole	.153656x108	.369163x1013	.339840X1013	.709005X1013
Dover sole	o.	.296136x108	.191014X1011	.191310X10 ¹¹
Rex sole	o.	.281752X108	.456244X108	.737996x10⁸
Rock sole	.499382X108	.423051x107	.712958x109	.767126x109
Sablefish				
Cottidae	.349567x109	.537339X1011	.644934x1011	.118576x1012
Pacific cod	.960351x106	.253707x1012	.619945x1012	.873653x1012
Walleye pollock	.297593x10¹¹	.179953X1014	.441407X1013	.224391x1014
Smelt	.147957X1011	.170079X1010	.238037x10 ¹⁰	.188768x10 ¹¹
Thornyhead				
Pacific ocean perch	o.	.337383x109	.656991x1010	.690730X1010
Tanner crab	.743351X1011	.234810X1012	.131613x1014	.134705X1014
King crab	.256901x1012	.700573X1010	o.	.263907x1012

Table 28.--Variances of the biomass estimates for **the Chirikof** region for April-October 1975, Cr 753.

Species	Depth Zones (m)			Total
	0-100	101-200	201-400	
Elasmobranchs	0.	.633658x10 ¹¹	.279793x10 ¹²	.343159X10 ¹²
Flatfishes	.636401x10 ¹³	.967328x10 ¹³	.276740X10 ¹⁴	.437113X10 ¹⁴
Roundfishes	.224924x10 ¹⁴	.100949X10 ¹⁷	.110185x10 ¹⁴	.101284x10 ¹⁷
Rockfishes	.165263x10 ⁸	.303525x10 ¹³	.172313x10 ¹¹	.305249x10 ¹³
Invertebrates	.266577x10 ¹⁴	.356429x10 ¹³	.191469X10 ¹³	.321377x10 ¹⁴
Skates	0.	.633658x10 ¹¹	.279793x10 ¹²	.343159X10 ¹²
Turbo t	.225781x10 ¹²	.287602x10 ¹³	.152952x10 ¹⁴	.183970X10 ¹⁴
Halibut	.232164x10 ¹³	.490772x10 ¹⁰	.254544x10 ¹³	.487199x10 ¹³
Flathead sole	.181231x10 ¹³	.210940x10 ¹³	.204643x10 ¹³	.596814x10 ¹³
Dover sole	.734505X10 ⁹	.170885x10 ¹¹	.180971x10 ¹²	.198794x10 ¹²
Rex sole	.712863x10 ¹⁰	.136831x10 ¹²	.129051x10 ¹²	.273010x10 ¹²
Rock sole	.624014x10 ¹²	.887214x10 ¹²	.222144x10 ⁹	.151145X10 ¹³
Sablefish	.734505X10 ⁹	.574080X10 ⁹	.763269x10 ¹¹	.776355x10 ¹¹
Cottidae	.927338x10 ¹²	.998009X10 ¹²	.302735x10 ¹¹	.195562x10 ¹³
Pacific cod	.555862x10 ¹¹	.132034x10 ¹³	.516274x10 ¹³	.653867x10 ¹³
Walleye pollock	.194309X10 ¹⁴	.116507x10 ¹⁷	.793793X10 ¹²	.116710X10 ¹⁷
Smelt	0.	.103167x10 ⁹	.921251x10 ⁹	.102441x10 ¹⁰
Thornyhead	0.	0.	.409357x10 ⁸	.409357x10 ⁸
Pacific ocean perch	0.	.335215x10 ¹³	.459390X10 ⁹	.335261x10 ¹³
Tanner crab	.483514x10 ¹²	.147442x10 ¹³	.609987x10 ¹¹	.201893x10 ¹³
King crab	.182125x10 ¹⁴	.300593X10 ¹²	.785193x10 ¹¹	.185916x10 ¹⁴
Scallop	.459066x10 ⁸	0.	0.	.459066x10 ⁸

Table 29.--Variances of the biomass estimates for the **Sanak region** for April-October 1974, Cr 744.

Species	Depth Zones (m)			Total
	0-100	101-200	201-400	
Elasmobranchs	O.	.211434x10 ¹³	.108611x10 ¹¹	.212520x10 ¹³
Flatfishes	.183311x10¹⁵	.669666x10 ¹⁴	.108633x10¹⁴	.261141x10 ¹⁵
Roundfishes	.449676x10 ¹⁵	.827767x10 ¹⁶	.171556x10¹⁴	.874450x10 ¹⁶
Rockfishes	O.	O.	.106859x10 ¹³	.106859x10¹³
Invertebrates	.269603x10¹⁴	.150797x10 ¹⁴	.109866x10 ¹⁴	.530268x10¹⁴
Skates	O.	.211434x10 ¹³	.108611x10¹¹	.212520x10 ¹³
Turbot	.195209x10 ¹⁴	.233838x10 ¹⁴	.115626x10 ¹⁴	.544674x10 ¹⁴
Halibut	.599668x10¹²	.289815x10¹²	.356968x10 ⁹	.889840x10 ¹²
Flathead sole	.509291x10 ¹²	.297302x10¹⁴	.413776x10 ¹¹	.302809x10 ¹⁴
Dover sole	O.	.147159x10¹²	.110541x10 ¹²	.257700x10¹²
Rex sole	.386653x10¹¹	.320905x10 ¹⁴	.750892x10 ¹¹	.322043x10 ¹⁴
Rock sole	.120489x10 ¹⁵	.198191x10¹⁴	.356968x10 ⁷	.140308x10 ¹⁵
Sablefish	O.	.279819x10 ¹⁰	.520239x10 ¹¹	.548221x10¹¹
Cottidae	.171498x10 ¹⁴	.279836x10¹³	.514035x10 ⁸	.199482x10 ¹⁴
Pacific cod	.151804x10 ¹⁵	.273378x10 ¹⁴	.539772x10 ¹¹	.179195x10 ¹⁵
Walleye pollock	.499554x10 ¹⁵	.855920x10 ¹⁶	.165474x10 ¹⁴	.907530x10 ¹⁶
Smelt	.415118x10 ⁷	.168660x10 ¹²	O.	.168664x10 ¹²
Thornyhead	O.	O.	.353421x10 ¹²	.353421x10 ¹²
Pacific ocean perch	O.	O.	.273706x10 ¹²	.273706x10 ¹²
Tanner crab	.580597x10 ¹³	.314039x10 ¹³	O.	.894636x10 ¹³
King crab	.116574x10 ¹⁴	.815599x10 ¹³	O.	.198134x10 ¹⁴
Scallop	O.	.188318x10 ¹¹	O.	.188318x10¹¹

FINAL REPORT

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Beaufort Sea Estuarine Fishery Study

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31 October 1977

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Beaufort Sea Estuarine Fisheries Study

This report presents data collected between 1975 and 1977. The report is divided into three parts. Part one covers field work conducted during 1975 and 1976 on the major objectives of this study. The second part is a supplemental report for 1977 presenting additional data on the timing and movements of **anadromous** fish near Prudhoe Bay. Part three lists overall conclusions of the three year study. Michael R. Doxey, Alaska Department of Fish and Game, authored the 1977 segment of this report.

SUMMARY

Fisheries surveys were conducted along 102 miles (163 km) of Beaufort Sea coastline between the Colville and Canning rivers over a two year period beginning in 1975. An attempt was made to sample all of the principal habitats within this study area. A total of 28,369 fish representing seven families and 15 species was captured. During the open water season freshwater and anadromous species dominated the near shore fish fauna and accounted for 52% of the entire catch. Arctic char, Salvelinus alpinus, Arctic cisco, Coregonus autumnalis, and least cisco, C. sardinella, were the most widespread and abundant anadromous fishes. The two most abundant marine species are fourhorn sculpin, Myoxocephalus quadricornis and Arctic cod, Boreogadus saida.

During 1976, 4,962 anadromous fish were tagged with Floy FD-67 anchor tags. Eight percent (384) were recaptured within the study area and in the Colville River. Anadromous fish enter the Beaufort Sea at breakup and forage for variable distances along the coastline. Adults reenter freshwater systems to spawn and overwinter earlier than juveniles and nonspawning members of the same species. The movements of juvenile fish along the coastline are restricted to less saline, protected waters of major river deltas and lagoons. Anadromous whitefish and char spawn during the fall in a variety of river habitats ranging from perennial groundwater springs in headwater tributaries to isolated pockets of under-ice water in river deltas. Overwintering habitat has not been identified in the fast ice zone of the Beaufort Sea. Tag recoveries indicate that the Colville River is the major spawning and overwintering drainage for whitefish captured within the study area. The destruction or disturbance of overwintering and spawning habitat appears to present the greatest threat to survival of near shore anadromous fish populations along the Beaufort Sea.

In the final segment of the three year study in 1977 emphasis was placed on further defining migration patterns and timing of anadromous fishes in Prudhoe Bay,

During the period from mid-July to mid-August 5,160 fish of eleven species were captured with fyke nets. A total of 2,324 anadromous fish were captured and 941 were tagged.

Movement patterns were similar to those noted in 1976, but numbers captured were down considerably from the 6,354 anadromous fish captured during the same period in 1976 with approximately the same effort.

Much higher salinities in the bay (\bar{x} of 17.0 ppt) in 1977 than those recorded in 1976 (\bar{x} of 7.5 ppt) were given as a probable cause for the decrease in fish numbers and it was suggested that many fish may have remained in less saline environments, e.g. river mouths during the study period. Tag returns for the least cisco, Coregonus sardinella, indicated a strong schooling behavior.

INTRODUCTION

Petroleum exploration and development is rapidly increasing throughout the near shore areas of the Beaufort Sea. The demands by industry for construction material, gravel sources, fresh water and transportation avenues are substantial. Alterations of the physical environment resulting from water and gravel removal or the construction of roads, pads and causeways are imminent. Information on the biology of fish inhabiting these waters is necessary prior to evaluating the ultimate effects these activities have on the resource.

The objectives of this study are to determine the distribution and relative abundance of the various species of fish inhabiting the near shore environs of the Beaufort Sea. By correlating important life history data with the knowledge of habitat needs, we hope to obtain baseline information that can be used to direct the activities of people and industry in the proposed lease area. Specifically, the objectives of the study are:

1. To determine the seasonal distribution, relative abundance, size and species composition, growth rates, feeding habits and reproductive capabilities of Beaufort Sea near shore fishes in the area from the **Colville** to the Canning rivers and between shore and the barrier islands, including river deltas.
2. To determine migration patterns and timing of these fishes.
3. To identify critical habitats including spawning, overwintering, feeding, rearing and migration areas.
4. To determine the interrelationship of Arctic fishes to lower food-web organisms.
5. To determine the present rate of exploitation of the **anadromous** fishes of the area and to monitor changes in this usage as development of the area's petroleum resource progresses.

CURRENT STATE OF KNOWLEDGE

Prior to the accelerated interest and development in the Arctic by major oil companies, there have been few investigations of the fishes in the Beaufort Sea. The Alaska Department of Fish and Game (**Roguski and Komarek**, 1971) initiated a study to assess the environmental characteristics and fish species in coastal waters of the Arctic National Wildlife Range. The following year, a four year investigation of the waters draining into Prudhoe Bay was initiated (**Yoshihara**, 1972, 1973 and **Furniss** 1974, 1975). These investigations emphasized the life histories and distributions of **anadromous** species with special emphasis on Arctic char. Other fisheries studies on North Slope drainages were conducted

by McCart, Craig and Bain (1972) and Johnson (1973). With the advent of designing and proposing utility corridors to transport natural gas south from the Arctic, several more investigations were initiated, many of which stressed the life history and biology of fish in their freshwater habitats of North Slope drainages. More recently, fisheries investigations have been centered along the northern coastlines of Alaska and Canada. Furniss (1975) investigated the age, growth, fecundity, species composition and distribution of fishes in Prudhoe Bay. Doxey (1977) conducted a study under contract to the Atlantic Richfield Company to determine the effects of a newly completed Prudhoe Bay causeway on fish movements and timing. Griffiths and Craig et al. (1975) conducted a site specific study of the fishes in the Nuneluk Lagoon, along the Arctic coast of the Yukon Territory. Griffiths et al. (1976) conducted a similar study at Barter Island, and other investigators have conducted studies aimed at evaluating the importance of the Mackenzie (Percy, Eddy and Munro, 1974) and Colville (Kogl and Schell, 1975) river deltas to Arctic Ocean fish. Studies of overwintering fish in the Arctic have been directed towards the larger bodies of fresh water, including river deltas (Mann, 1975; Kogl and Schell, 1975) and spring areas or unfrozen pockets of river water under thick ice (Craig and McCart, 1974; Alt and Furniss, 1976). These studies have led to a much greater understanding of the habitat requirements and life histories of Arctic fishes; however, much remains to be understood of these fishes during their seasonal occupation of the shallow near shore environments along the Beaufort Sea coast.

STUDY AREA

The OCS Beaufort Sea studies encompass an area between the eastern margin of Harrison Bay and Flaxman Island, a linear distance of approximately 102 miles (163 km) (Fig. 1). Centrally located along this stretch of coastline is Prudhoe Bay, the development and staging area for North Slope oil fields and the beginning of the **Trans-Alaska** oil pipeline. A barrier island system consisting of raised pebble reefs extends intermittently along the entire length of the study area. These islands, lying from 1/2 to 12 miles (1-16 km) offshore, tend to prevent large quantities of fresh water and nutrients entering the Beaufort Sea from readily mixing with the cooler, more saline waters of the Arctic Ocean. They also shelter the mainland coastline from pack ice during the summer months, thus providing a low salinity, relatively ice-free lagoon system inhabited by several species of **anadromous**, freshwater or marine fish throughout much of the year. Physical features of the mainland coastline include river deltas, spits, shallow bays, and narrow pebble or fine sediment beaches. Direct wave action and thermal erosion of permanently frozen shore banks produce local beaches composed of humus and decayed vegetation. Sharp variations in water temperatures and salinities were noted, both between short distances and with time, during the open water season (Fig. 2). Physiographic and environmental characteristics of the Beaufort Sea and coast are described by Namtvedt, et al. (1974) and State of Alaska, Division of Policy Development and Planning (1975).

Figure 1. Map of Alaska showing North Slope Study Area.

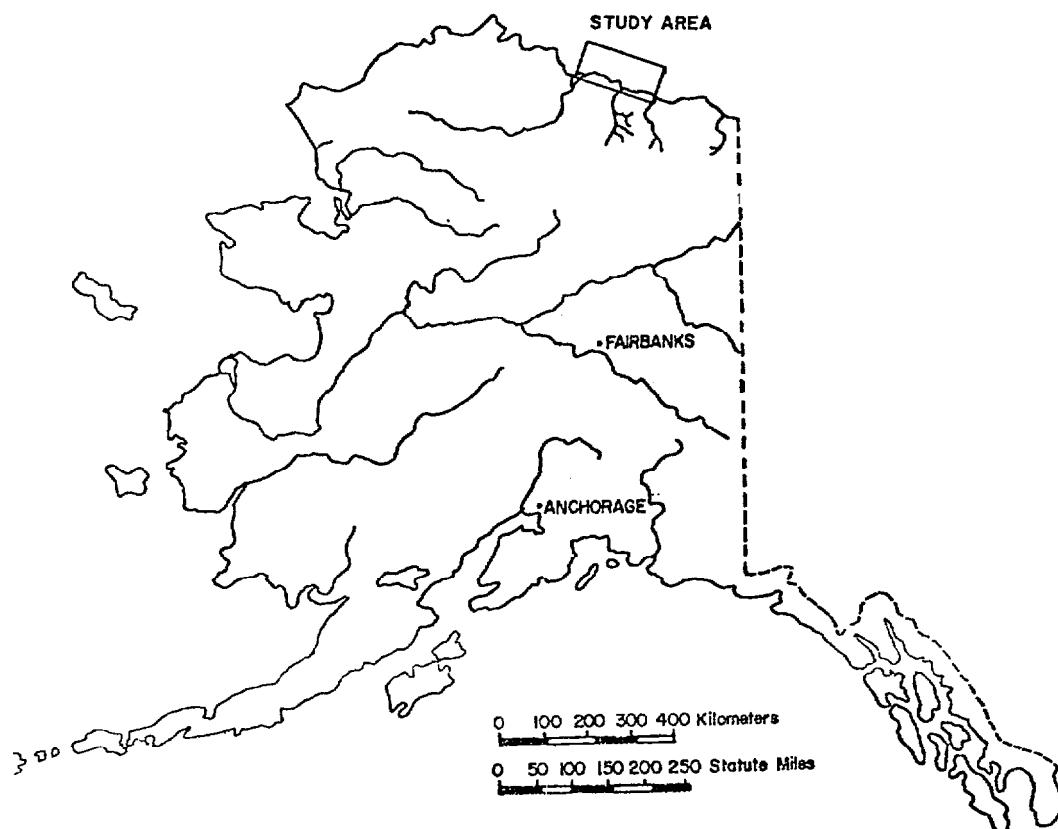
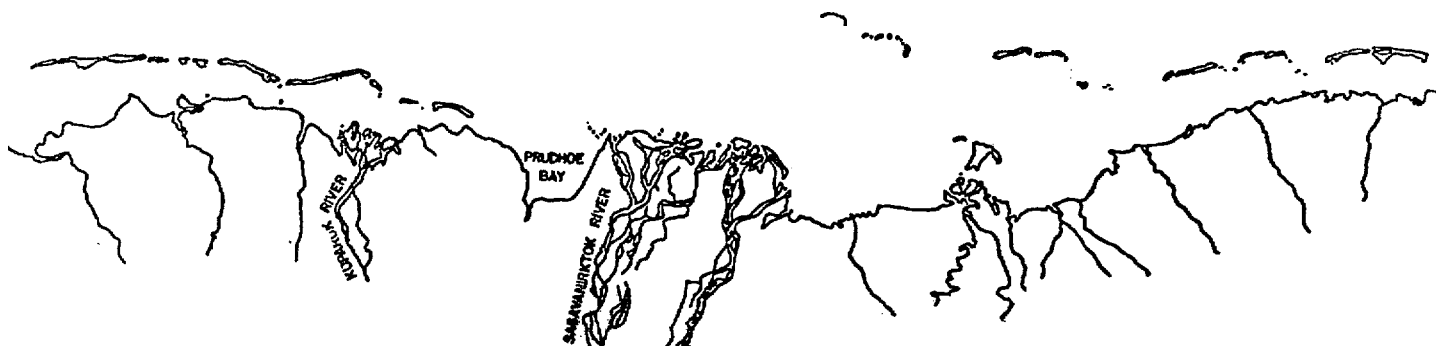
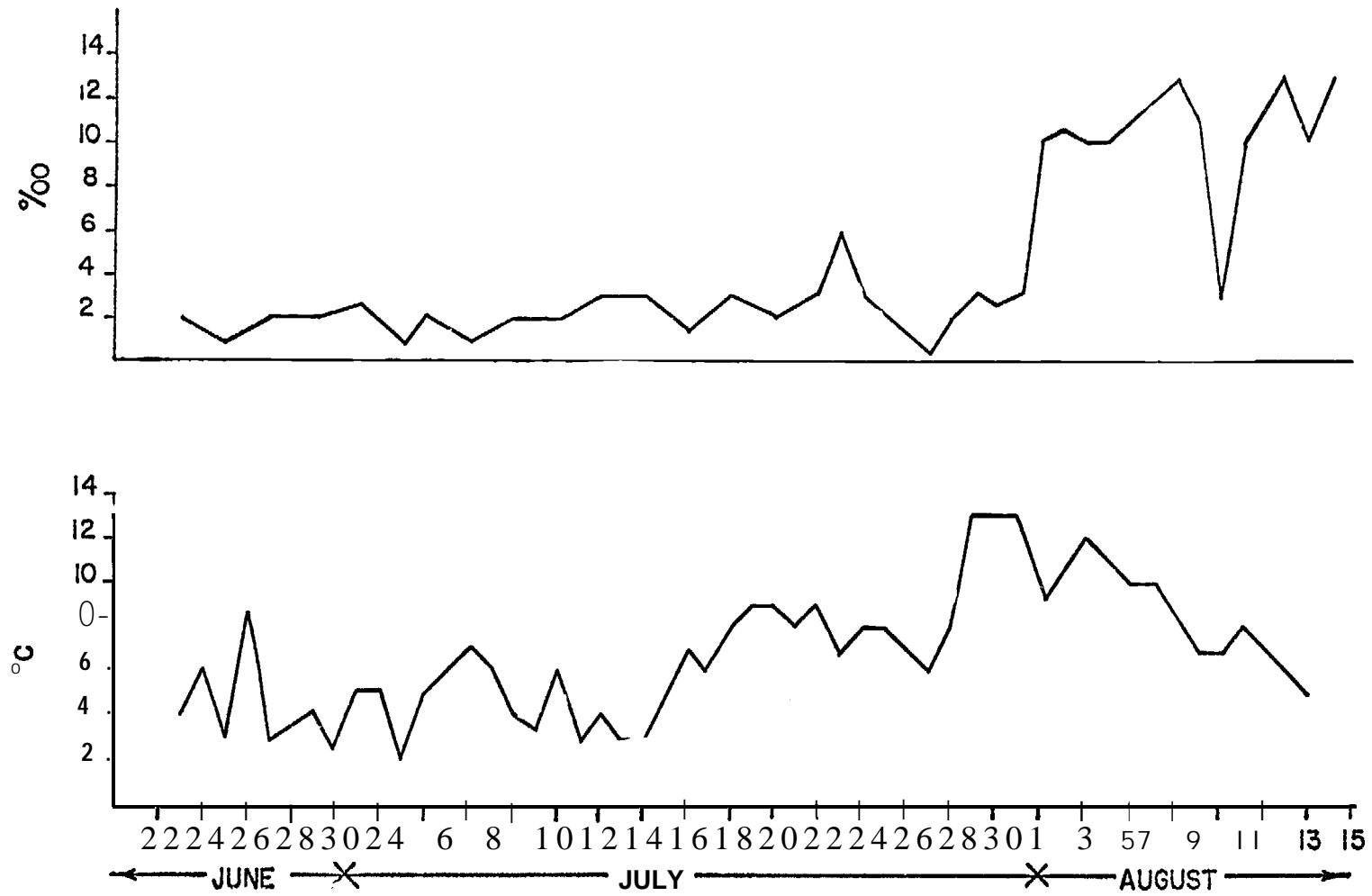


Figure 2. Seasonal variation in salinity and temperature at Prudhoe Bay, 1976.



SOURCES, METHODS AND RATIONALE OF DATA COLLECTION

Methods of Capture and Observations

Multifilament graduated mesh sinking gill nets measuring 125' x 6' and consisting of five 25' panels of 1/2' through 2 1/2" mesh were used for capturing and sampling fish. Multifilament gill nets measuring 25' x 3' and consisting of single mesh sized from 1/2" to 1 1/2" were used for capturing fish during under-ice surveys.

Beach seines measuring 100' x 4' were used to sample fish in confined locations within small bays and lagoons, and along exposed beaches where water was sufficiently shallow to allow the seaward end of the seine to be maneuvered on foot.

Fyke traps were operated at several locations within Prudhoe Bay. Traps were 20' in length overall and were supported by five "D^f" shaped, 3/4" aluminum tube frames. Two throats measuring 10" in diameter were located at the first and third frames. Netting was 1/2" square mesh knotless nylon. The fyke traps were anchored in approximately 4' of water and were attached to **shore** by 50', 100' or 150' center leads. Two 25' x 4' wings funneled fish into the trap.

A try trawl measuring **12' in width** and constructed with 3/4" square measure knotted nylon mesh was used to sample fish offshore.

Hook and line sampling was employed to capture fish in river deltas and under the ice.

An underwater closed circuit television system was used under the ice in the Sagavanirktok and **Kuparuk** river deltas to detect and observe **over-**wintering fish occupying isolated pockets of unfrozen water. The system is sold by Hydro Products, Box 2528, San Diego, California. Its operation employed the use of the following five components:

- Underwater television camera with 12.5 mm optics
- High resolution 9" monitor
- Gas discharge lamp ballast
- 250 watt Thallium iodide lamp
- Portable 115 V power source

A Yellow Springs Instrument Co. salinity meter was used to determine water temperature, salinity and conductivity. Wind force and direction, current force and direction, sea state, cloud amount, present weather and air temperature were observed and recorded daily throughout most 1976 open water season.

Anadromous fish over 200 mm in fork length that were not sampled were tagged with numbered Floy **FD-67** internal anchor tags. All other fish, including those below the "minimum" tagging size that were not sampled, were noted on daily catch forms and released.

A 21' Boston whaler and a 12' Zodiac inflatable boat were used for trawling and setting nets offshore near Prudhoe Bay.

Rotary wing aircraft were used for transporting field personnel and gear for monitoring movements of fish along the coastline and into river deltas.

Processing of Fish

Fish samples were preserved in 10% Formalin or frozen and sent to Fairbanks via commercial airlines for further laboratory analysis. All samples were grouped by date and location. Fish were weighed to the nearest gram on a triple-beam balance. Fork lengths were measured to the nearest millimeter. Sex and stage of maturity were determined by examining gonads,

Fecundity counts were determined by displacing a volume of water with a known quantity of eggs. The total number of eggs was then calculated using the quantity of water displaced by the entire ova mass.

Arctic char, cod, flounder, sculpins and liparids were aged by reading otoliths wetted in xylene under a binocular dissecting scope. Scales were used to age all other species. Scales used for age determination were cleaned and impressed on 20 mil acetate sheets. A Bruning 200 microprojector was used to read the scales. Lengths at the end of each year of life for several species were back calculated using the direct proportion formula.

Selected fish stomachs were slit and preserved in 10% Formalin. The gut contents were later examined, sorted and identified.

Data Management

Raw data collected for this study have been prepared within the design of the OCSEAP data management format and stored on magnetic tape. Voucher specimens of the fish, invertebrates and food items collected during this study are in storage at the Fairbanks office of the Department of Fish and Game.

FINDINGS - 1975 to 1976

Species Composition and Relative Abundance

Seventy-six sampling sites were established between the eastern margins of Harrison Bay (70°33' N, 149°38' W) and Brownlow Point (70°10' N, 145°53' W) (Fig. 3). An attempt was made to sample all of the dominant habitat types within this area. These include outer islands, near shore islands, spits, points, bays, lagoons and river deltas. Salinity, water and air temperature, conductivity and depth of water were recorded at each station. During the summer of 1976 the following additional parameters were recorded at each site: bottom type, present weather,

The figure consists of three maps showing sampling locations in the Beaufort Sea and surrounding regions. The top map shows the Beaufort Sea with numerous sampling points labeled with codes like 014-76, 025-76, 013-76, etc. The middle map shows the Arctic region with sampling points labeled with codes like 003-75, 032-76, 034-75, etc. The bottom map shows a detailed view of a coastal area with sampling points labeled with codes like 11-76, 12-76, 18-76, etc.

cloud amount, sea state, wind direction, wind force, current direction and current force. These additional parameters were observed rather than measured and were recorded as prescribed by the fish resource assessment format designed and provided by OCS.

A total of 28,369 fish representing seven families and 15 species has been captured. Fish species captured between Harrison Bay and Brownlow Point are listed in Table 1.

During 1975, graduated mesh gill nets were the most extensively used method of capture; however it became obvious late in the season that the use of gill nets was not conducive to the capture of gadids, liparids and the early life stages of salmonids. Fyke traps were subsequently stationed at several locations in Prudhoe Bay and proved more effective at catching the above mentioned fishes. During 1976, an attempt was made to maintain several fyke trap stations throughout the open water season in Prudhoe Bay while graduated mesh gill nets were used for 24 hour sets at more remote stations requiring helicopter transportation. Fyke traps also proved to be the least harmful method of capturing fish for tagging studies.

Beach seines effectively captured fish in shallow waters; however, adverse weather conditions and wave activity frequently prohibited their use. A shrimp trawl was used in Prudhoe Bay. Transects were run for 20 minutes with the lead line of the trawl riding on the bottom. Larval and early life stages of Arctic cod, capelin and liparids dominated the offshore trawl catches.

The most widespread group of fishes captured along the coast were salmonids; Arctic char were captured at 75% of the gill net stations. Arctic cisco and least cisco were captured at 59% and 44% of the stations respectively. Least cisco were captured in the greatest abundance however, followed by Arctic char and Arctic cisco. Figure 4 shows the seasonal abundance of Arctic char, least cisco and Arctic cisco captured in Prudhoe Bay.

Catch data show a more widespread distribution for adult Arctic char and Arctic cisco than for other anadromous species. Arctic char and Arctic cisco were captured at nearly all of the barrier island stations as well as along mainland beaches. Least cisco, however, showed a greater affinity for near shore areas throughout the study area. Broad whitefish were rarely captured in waters east of Bullen Point (70°10' N, 146°45' W) and were found in the greatest abundance near the Sagavanirktok and Colville river deltas. Adult humpback whitefish were likewise distributed along mainland beaches between the Sagavanirktok and Colville rivers.

Figure 5 shows the relative abundance of all species captured within the study area. The majority of fish were captured in fyke traps set in locations adjacent to the mainland. The two most abundant marine species (Arctic cod and fourhorn sculpin) accounted for 48% of the entire catch. Figure 6 shows the seasonal distribution of all species captured in Prudhoe Bay.

Table 1. List of near shore species captured between Harrison Bay and Brownlow Point.

Scientific Name	Common Name	Species Abbreviation	Ocs Species Code
Salmonidae			
<u>Salvelinus alpinus</u>	Arctic char	AC	7904010402
<u>Coregonus sardinella</u>	Least cisco	LC I	7904010105
<u>C. autumnalis</u>	Arctic cisco	ACI	7904010101
<u>C. nasus</u>	Broad whitefish	BWF	7904010103
<u>C. pidschian</u>	Humpback whitefish	HWF	7904010104
<u>Prosopium cylindraceum</u>	Round whitefish	RWF	7904010601
<u>Thymallus arcticus</u>	Arctic grayling	GR	7904010701
Osmeridae			
<u>Osmerus mordax</u>	Boreal smelt	BSM	7904020302
<u>Mallotus villosus</u>	Capelin	CAP	7904020201
Gadidae			
<u>Boreogadus saida</u>	Arctic cod	ACD	7909020201
<u>Eleginus gracilis</u>	Saffron cod	SCD	7909020301
Cottidae			
<u>Myoxocephalus quadricornis</u>	Fourhorn sculpin	FSC	7915042206
Pleuronectidae			
<u>Liopsetta glacialis</u>	Arctic flounder	AFL	7917021101
Gasterosteidae			
<u>Pungitius pungitius</u>	Ninespine sticklebacks	NSB	7914010201
Liparidae			
<u>Liparus</u> sp.	Snailfish	Lip	791506

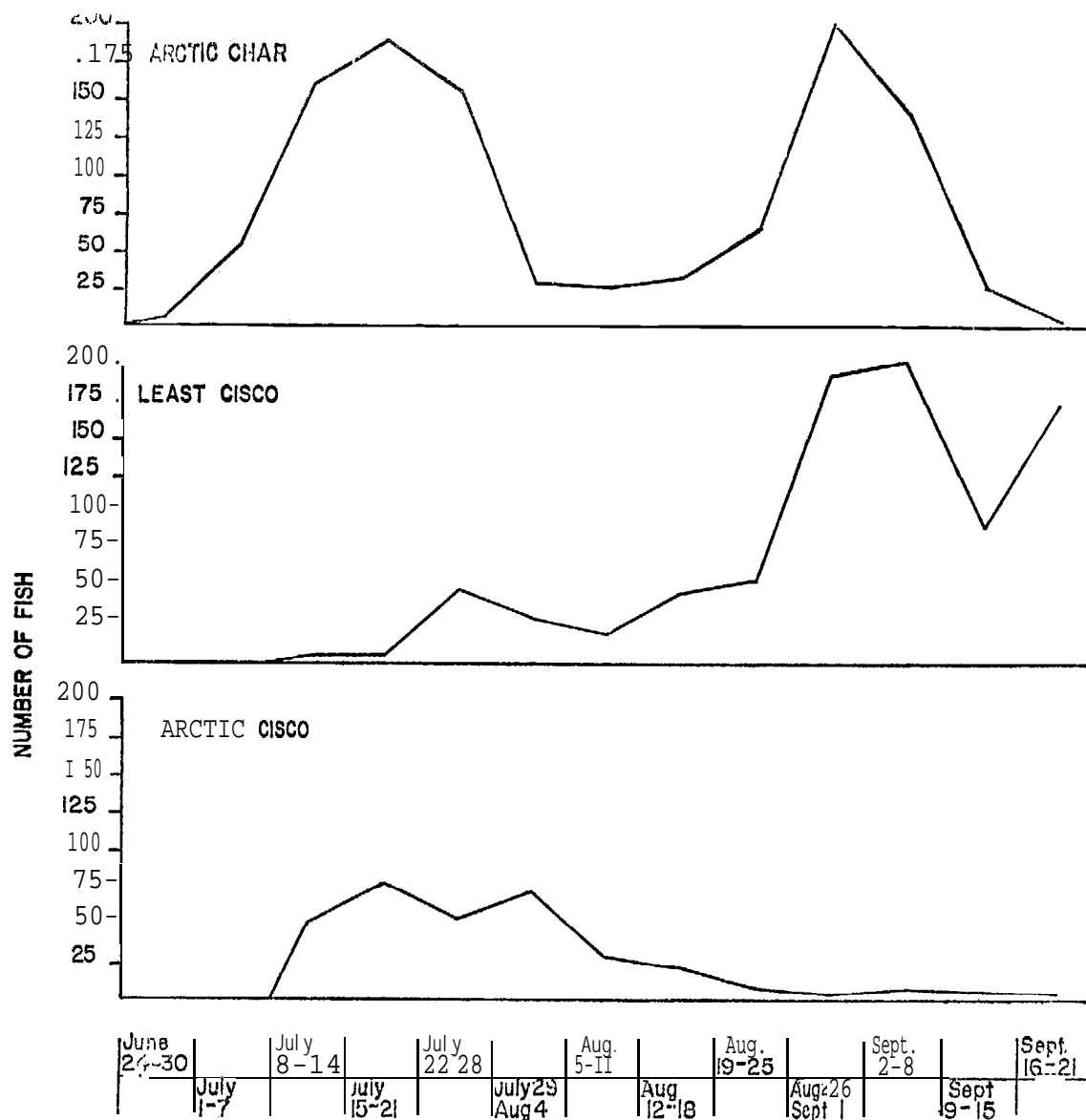


Figure 4. Seasonal abundance of three anadromous fish species in Prudhoe Bay.

Figure 5. Relative abundance of freshwater, anadromous and marine fish found in Prudhoe Bay.

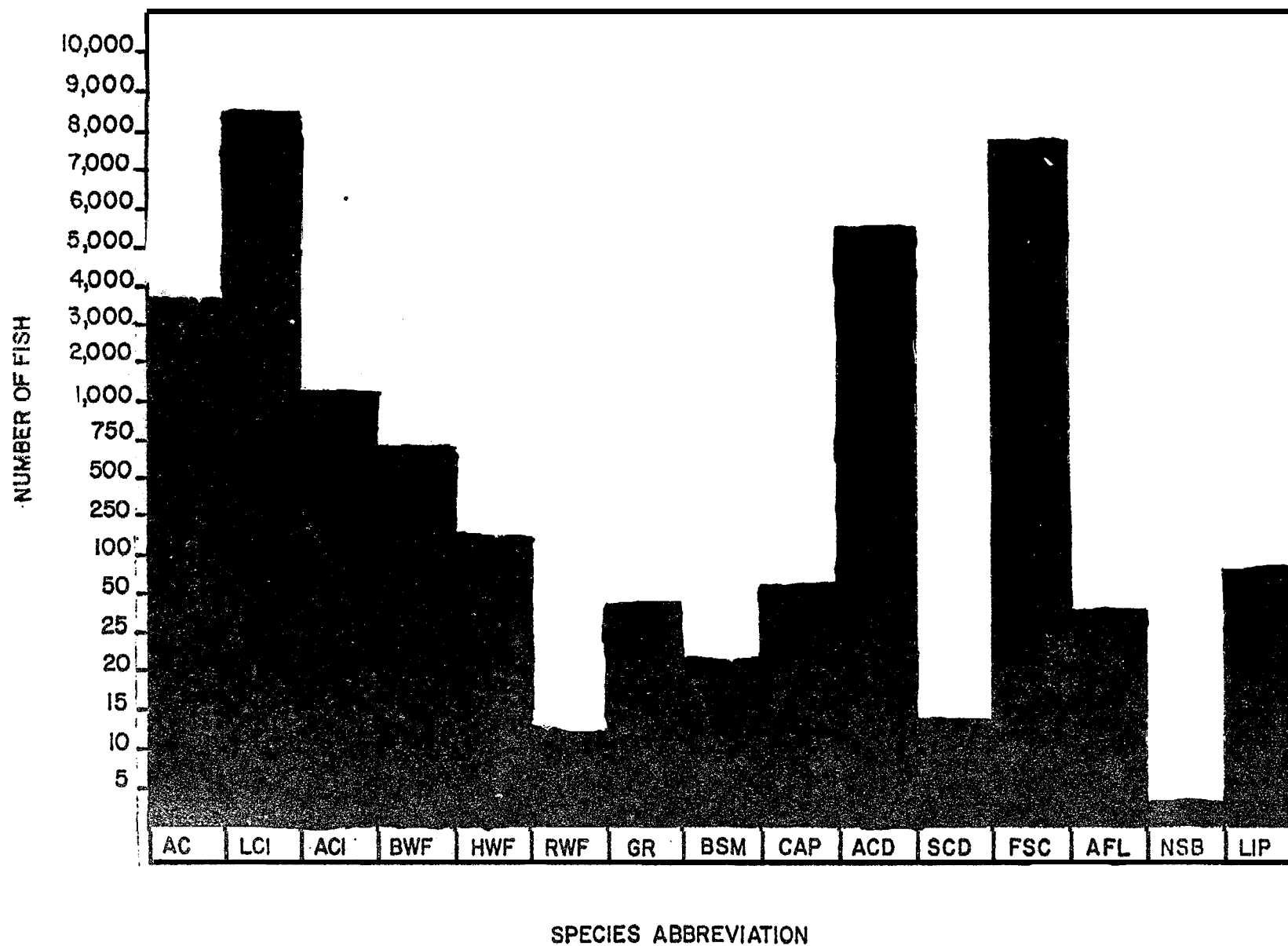
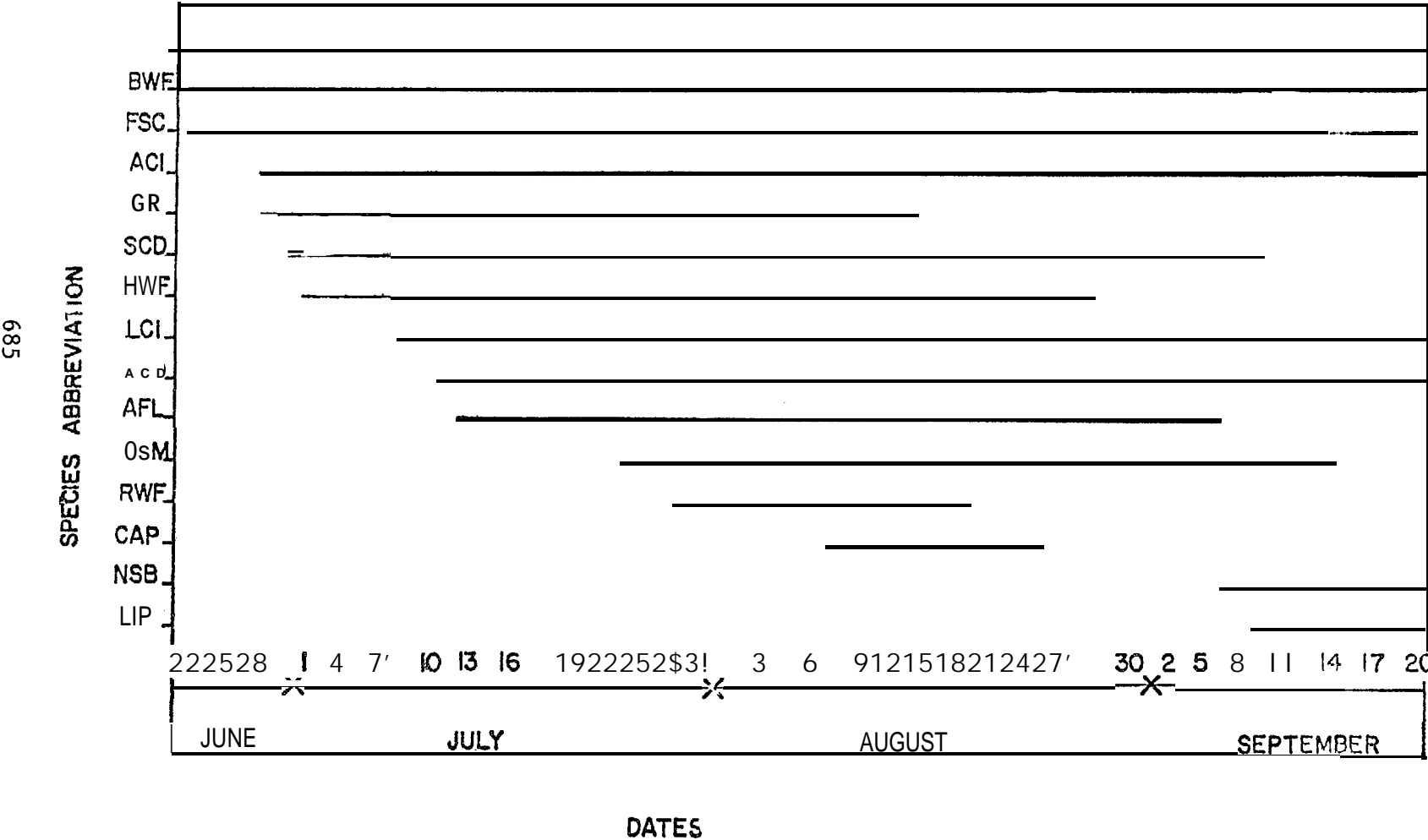


Figure 6. Seasonal distribution of fish species captured in Prudhoe Bay, 1976.



Migration Patterns and Timing 1975-1976

The presence of bottom-fast ice during winter months over much of the near shore waters between the mainland and the barrier islands precludes the presence of fish near shore until after breakup. During both years of this study, sea ice began lifting during the early weeks of June. During 1976, breakup occurred several weeks earlier in the rivers than in Prudhoe Bay. Fresh turbid water from the Sagavanirktok River flooded bottom-fast sea ice in the vicinity of the delta beginning approximately the first of June. Shortly thereafter, gill nets and fyke traps were set in open water leads as they appeared near shore in Prudhoe Bay. By June 21, the open water along the 'western margin of Prudhoe Bay (vicinity of ARCO causeway) was 1°C and the salinity was less than 1 ppt, indicating that the sea ice had not yet lifted and that fresh, river water was not mixing with the more saline waters of the ocean. The first fish captured in Prudhoe Bay were Arctic char and broad whitefish on June 22. By June 24, salinity increased to 2.5 ppt along the eastern margin of Prudhoe Bay and the first marine species (fourhorn sculpin) was captured. Throughout the remainder of June, Prudhoe Bay catches consisted of Arctic char, grayling, broad whitefish and fourhorn sculpin. Catches of Arctic cisco, humpback whitefish and saffron cod began in the first week of July. Least cisco, Arctic cod and Arctic flounder appeared in Prudhoe Bay during the second week of July. Both species of smelt found in the study were initially captured near shore in late July and early August, and the liparids were captured near shore for the first time on September 8. Throughout the open water season, short term variations in temperature and salinity did not affect the distribution or abundance of fish captured in Prudhoe Bay.

During 1976, 4,962 anadromous fish were tagged in Prudhoe Bay and 384 (8%) were recaptured within the study area and in the Colville River. The total number of fish captured at the permanent stations in Prudhoe Bay increased slowly throughout the 1976 open water season, reaching a peak during the first week of August. The length frequency distribution of the five anadromous species (Arctic char, least cisco, Arctic cisco, broad whitefish and humpback whitefish) found in Prudhoe Bay varied throughout the open water season. All of the above species that were greater than 200 mm in fork length that were captured in fyke traps were tagged with FD-67 Floy tags. Thus, we could segregate the number of each species captured into two rough size groupings; those greater than 200 mm which were subsequently tagged and those less than 200 mm which were accounted for and released. During the month of June, 24% of the above species combined were greater than 200 mm. In July, August and September, 41%, 74%, and .08% of the anadromous fish captured were greater than 200 mm in fork length. Thus the percentage of larger and older fish of each species increased throughout the summer to a peak in early August, then decreased very rapidly and remained low until the time the traps were removed (September 22). The decrease in the percentage of larger fish corresponds with the timing of mature individuals movement back into fresh water spawning and overwintering habitats. In both years of this study, immature Arctic char and least and Arctic cisco remained in the salt water until freezeup. Of the marine species

captured, only fourhorn sculpin, Arctic cod and liparids were taken after September 1. More detailed information on distribution and movements follows in the discussion of individual species.

Overwintering Habitats

Very little information is available concerning overwintering fish and their habitat in Arctic and subArctic waters. The two major rivers within the study area (Sagavanirktok and Kuparuk) attain maximum rates of discharge during spring breakup. Thereafter, the flow decreases throughout the remainder of the year. Freezepup usually occurs in September. As the river ice increases in thickness, it freezes into the substrate in shallow areas and riffles. By mid winter, this process has effectively created a series of discontinuous pools of water under the ice which constitute the only overwinter habitat for fish occupying the lower reaches of these rivers. Late winter flows in the Sagavanirktok and Kuparuk deltas are poorly defined, but near zero.

Ten locations were examined for overwintering fish between March 18 and April 10, 1976 (Fig. 7). The following parameters were recorded at each site: ice depth, water depth, bottom type, approximate dimensions of under-ice pool, air temperature, water temperature, salinity and dissolved oxygen. Observations of fish under the ice were made with the under-water closed circuit television system. Fish were captured by hook and line and with gill nets. The use of minnow traps to capture juvenile fish was tried unsuccessfully at several locations. Up to 28 man hours of effort were required to set a single 25' net under the ice.

Our initial investigation indicates that the amount of under-ice habitat is extremely limited during late winter and every location thoroughly examined was found to contain fish. Table 2 summarizes the data collected at each site. Dissolved oxygen readings varied between 7 ppm and saturation (in excess of 15 ppm at 0°C). Station 03 on the Sagavanirktok River was anaerobic in April. This may have resulted from industrial dewatering of this site in earlier winter. Salinity was zero at all river locations. Water depths varied between 7" (dewatered by industry) and 66". The maximum ice thickness was 89". Bottom types varied from sand to coarse gravel up to 3" in diameter.

Following is a list of the fish either observed, or captured during March and April, 1976.

Sagavanirktok River

Grayling
Round whitefish
Broad whitefish
Humpback whitefish
Burbot
Slimy sculpin
...

Kuparuk River

Grayling
Round whitefish
...
...
Burbot
Slimy sculpin
Ninespine sticklebacks

Figure 7. Winter sampling sites, 1976.

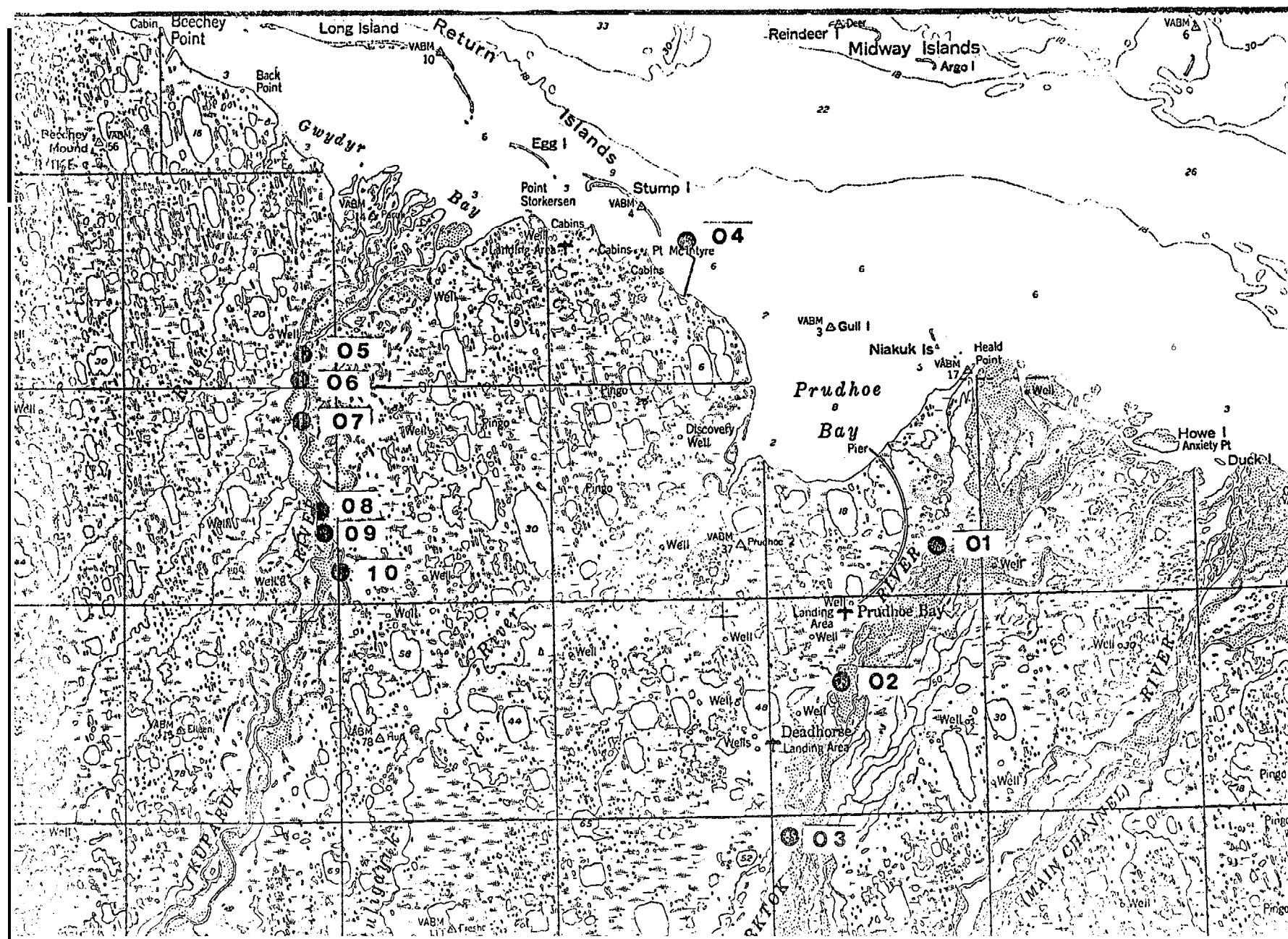


Table 2. Physical parameters recorded at overwintering sites 1976.

Station Number	Date	Location	Under-ice Water Depth (inches)	Ice Thickness (inches)	Water Temp. (°c)	Salinity (ppt)	DO (% saturation)	Species Present
01	3-19	Sagavanirktok R.	20	60	0	0	55	GR, RWF, BB, BWF, *HWF, SC
02	4-10	Sagavanirktok R.	41	89	0	0	100	GR, RWF, SC, BB
03	4-19	Sagavanirktok R.	27	65	0	0	0	GR
04	3-21	Prudhoe Bay	36	72	-1	30	N/A**	...
05	4-3	Kuparuk R.	62	66	0	0	>100	GR, BB, SC, NSB
06	4-3	Kuparuk R.	48	72	1.5	0	90	N/A*
07	4-5	Kuparuk R.	64	69	0	0	49	GR, BB, RWF
08	3-20	Kuparuk R.	20	84	0	0	>100	GR, BB, RWF, SC
09	3-20	Kuparuk R.	16	80	0	0	>100	N/A*
10	4-5	Kuparuk R.	46	66	0	0	>100	N/A*

* No attempt was made to observe with the camera or set a net.

** Dissolved oxygen values were not taken at this site.

Grayling captured under the ice averaged 279 mm in fork length and ranged from 35 mm (young-of-year) to 377 mm (X years). Females over 250 mm were **gravid**. All grayling had empty stomachs at the time of capture.

Round whitefish ranged from 217 mm to 284 mm in fork length with an average of 244 mm. Round whitefish ranged from IV through VI years in age and all had empty stomachs at the time of capture.

Broad whitefish ranged from 239 mm to 445 mm in fork length and averaged 380 mm. Ages ranged from V through XIII years. Broad whitefish from 370 mm to 445 mm had spawned the previous fall probably at or near the same location as captured under the ice. All of the broad whitefish had empty stomachs.

Burbot captured under the ice averaged 493 mm in fork length and ranged from 255 mm to 702 mm. Ages varied from V through XII years and mature individuals, upon examination, showed evidence of having recently spawned. Burbot were feeding on **grayling**, slimy **sculpin**, and ninespine **sticklebacks** as well as larval insects.

Several age groups of a species, and in some cases all species, were captured at the same site. The only species tentatively identified with an underwater camera but not captured was the humpback whitefish. Arctic char, an important species in the Sagavanirktok River, was neither observed nor captured under the ice in the lower river.

These preliminary results stress the importance of the limited **overwintering** habitat for fish in North Slope rivers. Under-ice pools of water serve as winter refuge for all age classes of the species present and provide spawning and incubation habitat for fall and winter spawners such as whitefish and **burbot**. Thus, overwintering habitat in North Slope river deltas is clearly susceptible to the deleterious effects of seismic activity, dewatering to meet domestic and industrial water needs, or chemical pollution.

A single under-ice location was examined in Prudhoe Bay on March 21 and 22, 1976. The substrate at this location was composed of mud and fine grained sediments. The underwater television camera showed a slight water current when the bottom sediments were disturbed. No fish were observed at this location. **Isopods** and several species of amphipods were moving within the water column throughout the duration of our underwater observation. Sufficient effort has not yet been made to determine the significance of near shore waters as overwintering habitat, however enclosed pockets of **hyper-saline** water within the fast ice zone appear to be the least suitable habitat for overwintering marine species.

INDIVIDUAL SPECIES DISCUSSION

Arctic Char

Arctic char have a circumpolar distribution. Morphological forms are varied and many distinct life history types occur within the range of this species,

Arctic char, found along the entire northern coast of Alaska, are the object of a traditional subsistence and expanding sport fishery. Several recent investigations have been conducted on the life history of the Arctic char in major North Slope drainages (Yosihara, 1973, 1974; Furniss, 1974, 1975; and Griffiths and Craig et al. 1975).

A total of 3,739 Arctic char was captured during 1975 and 1976. Fork lengths ranged from 154 mm through 685 mm with a mean of 427 mm. A length mode occurred between 520 and 529 mm. Length frequency distribution is shown in Fig. 8.

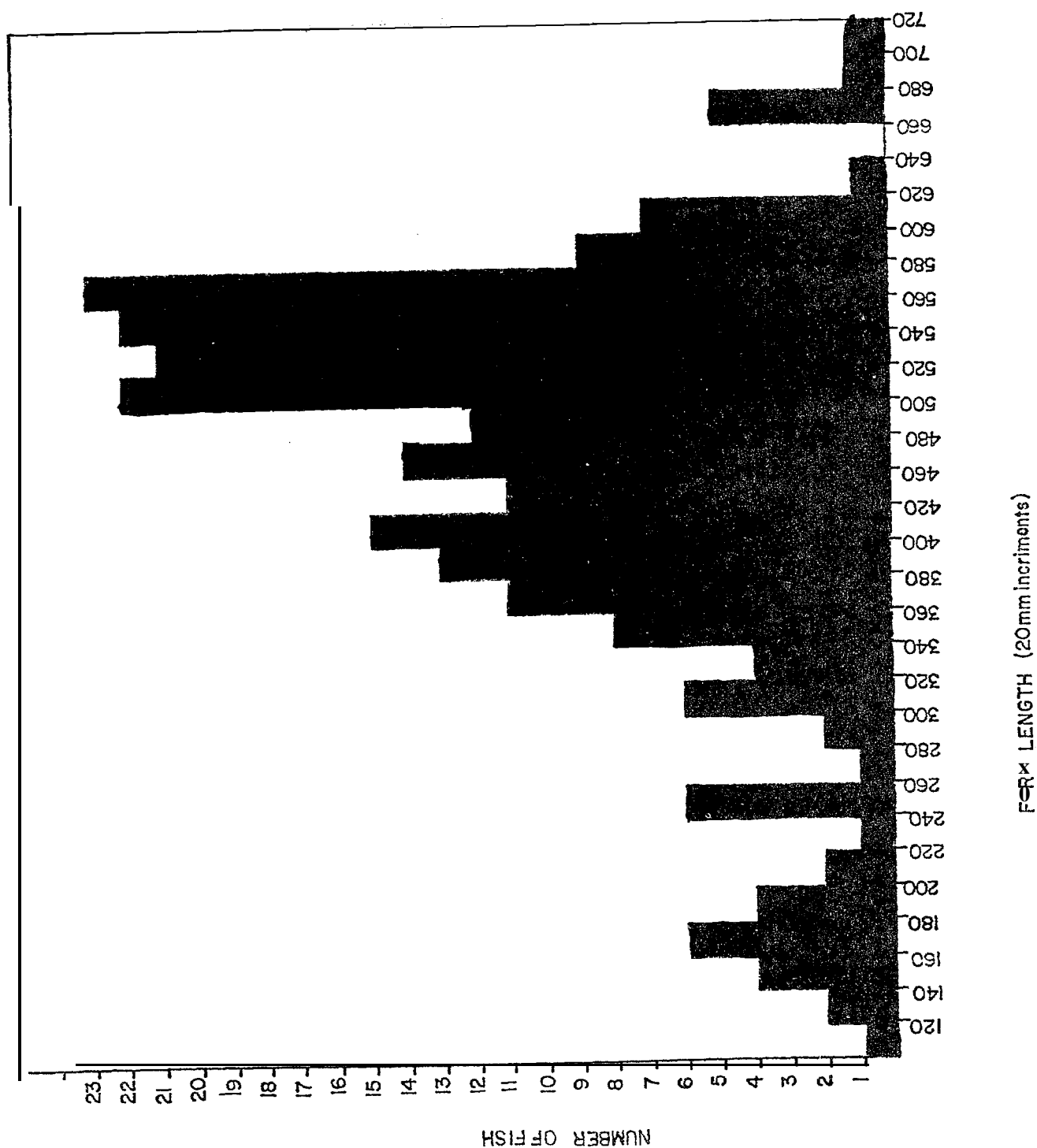
Arctic char ranged from Age III through Age XII, with the majority of fish between VII and IX. Juveniles less than 200 mm were abundant in the near shore waters between the Colville and Sagavanirktok rivers during the open water season.

Sexual maturity is reached from Ages VI to VIII for most **anadromous** char. Upon reaching maturity, most char spawn in alternate years (Yoshihara, 1973). The sex ratio of Arctic char captured within the study area was biased in favor of females. The female to male ratio of 235 Arctic char was 2:1. Similar disproportions in sex ratios of char were observed by Furniss (1975), Glova and McCart (1974) and others. Of 75 female anadromous char captured in the Beaufort Sea that were judged to be mature, 75% were prespawners (individuals that would spawn in the coming fall).

A total of 808 Arctic char was tagged in Prudhoe Bay during 1976 and 30 of these individuals were recaptured. Arctic char enter the Beaufort Sea at breakup and spread out along the coast in plumes of fresh river water that flood the fast ice. Char were first captured in Prudhoe Bay on June 22, 1976. The greatest number of char was captured during the month of July, and adults began entering the Sagavanirktok River to spawn and overwinter during the first week of August. Juvenile char (less than 200 mm) are present in the Beaufort Sea until freezeup and enter the Sagavanirktok River during September. Adult Arctic char forage widely during summer and were captured at the most remote barrier island stations. Previous studies (Furniss, 1975) indicate that char may travel as far as 300 km (from the Sagavanirktok River to Pt. Barrow) during the open water season. A limited amount of sport fishing effort by oil company employees primarily during July and August, was observed in Prudhoe Bay and the Sagavanirktok Delta.

Arctic char are opportunistic feeders and prey on a variety of epibenthic organisms as well as insect larvae and fish. Of 210 guts collected, 44%

Figure 8. Length frequency of Arctic char captured during 1975 and 1976.



were empty. Following is a list of food items from Prudhoe Bay char, omitting empty stomachs:

Amphipods	95%
Cod, <u>B. saida</u>	42%
Mysids	32%
Isopods	11%

Griffiths et al. (1975) working in Nuneluk Lagoon found char feeding on five species of fish (mostly fourhorn sculpin) as well as chironomid larvae, dipteran pupae and copepods.

Least Cisco

The least cisco is distributed throughout western North America and Siberia. It is a resident of many inland waters of Alaska and is anadromous in streams draining into the Bering, Chukchi and Beaufort seas.

The least cisco was the most frequently captured coregonid within our study area. The absence of least cisco in catches along the outer barrier islands suggests that this species has a strong affinity for brackish waters of the mainland coastline. Life history details of this species residing in northern waters are described by Mann, 1974; Kendel et al., 1974; Percy et al., 1974; and others.

A total of 8,545 least cisco was captured during 1975 and 1976. Fork lengths ranged from 82 mm through 364 mm with a mean of 272 mm (n=271). Figure 9 shows the length frequency of least cisco captured during this investigation. Females (n=216) were larger than males (n=66). The maximum lengths correspond well with least cisco captured in the Colville River (Kogl, 1971) and are lower than those described by McPhail and Lindsey, 1970.

Least cisco ages ranged from I through XII with VII through X individuals most frequently captured (Table 3). The growth rates of least cisco were lower than those reported from the MacKenzie River (Hatfield et al., 1972) and Interior Alaska (Alt, 1971). Figure 10 compares mean back calculated lengths for least cisco taken in Interior Alaska (Chatanika River) and the Beaufort Sea.

Sexual maturity begins at Age VII and 57% of the Age VIII least cisco were mature. Of those that were mature, 20% had redeveloping gonads and would not spawn in the year of capture, indicating that upon reaching maturity, a portion of the population will not spawn every year. The age of maturity of least cisco from the Beaufort Sea is from 1 to 2 years greater than reported from Siberia (Ber, 1948-49]. Spawning is reported to take place during fall in the lower reaches of major rivers. There were no spawning or overwintering areas located within the study area. Tag returns and movement patterns obtained during 1976 indicate that the majority of the least cisco captured along the coast move out of, and return to the Colville River.

Figure 9. Length frequency of least cisco captured during 1975 and 1976.

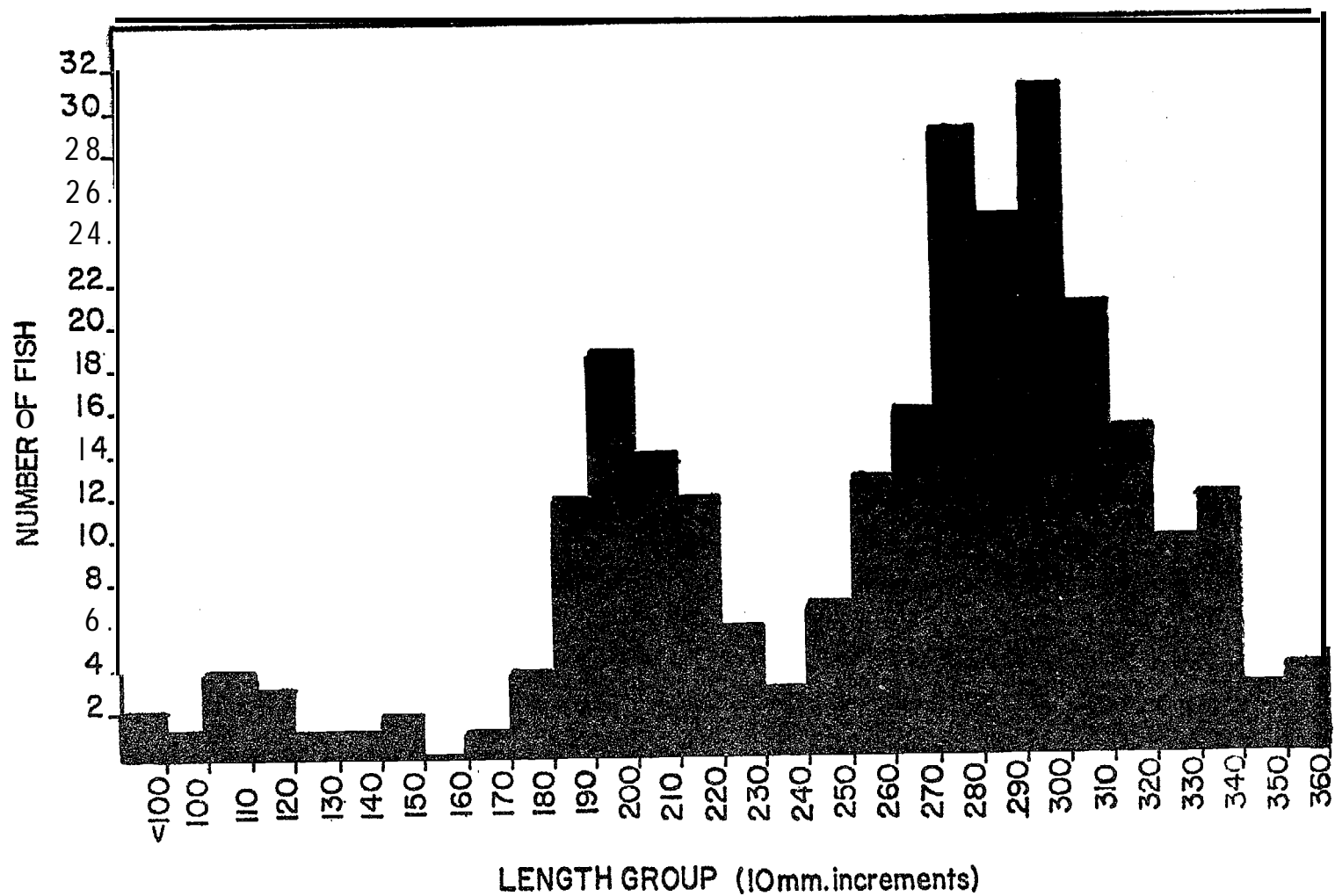
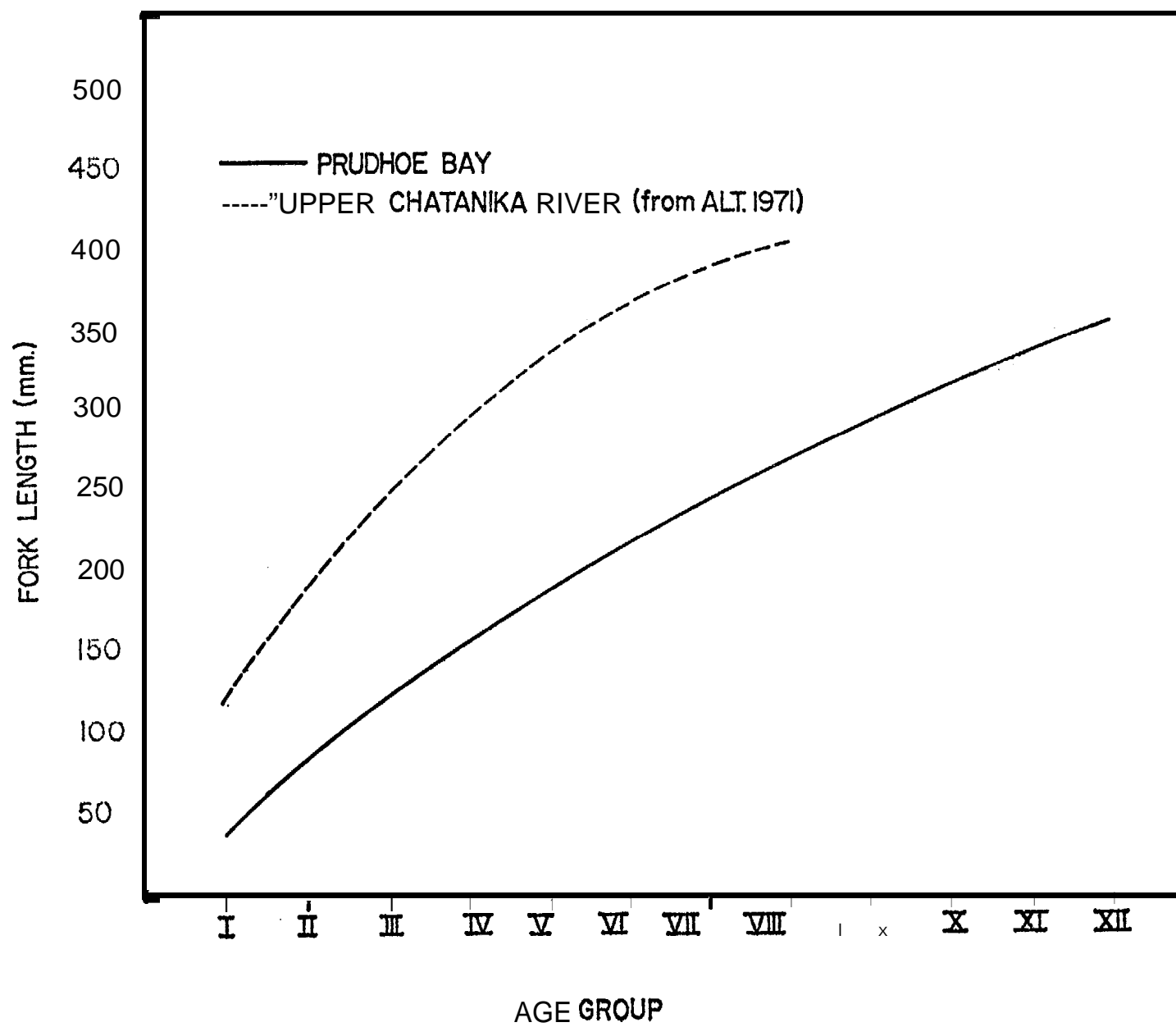


Figure 10. Back calculated fork lengths of least cisco taken in Prudhoe Bay and the Chatanika River (Interior Alaska).



In 1976, a total of 3,185 least **cisco** was tagged in Prudhoe Bay and 328 were recaptured within the study area and in the Colville River. Least **cisco** first appeared in Prudhoe Bay during the first week of July 1976. Their abundance increased to a peak during early September, however the greatest number of large fish (over 200 mm) was captured during the month of August. Although Age I and II least **cisco** were captured in Prudhoe Bay, it appears that most enter the brackish waters of the Beaufort Sea during their third year. Tagged individuals showed an eastward movement through Prudhoe Bay from breakup through mid-August and then generally westward movement until freeze-up. Several individuals were recaptured at various sites within Prudhoe Bay throughout July and August, indicating random movement within the same general area for an extended period of time. One least cisco was recaptured at Barter Island (250 km east of Prudhoe Bay). The migration of adults to the Colville River was first recorded in mid August when a least **cisco** tagged in Prudhoe Bay was captured in the Colville River seven days after being tagged. Eighty-two percent of the recaptured least **cisco** were taken during fall in the lower Colville River. Wohlschlag (1954), in comparing migratory and non-migratory least **cisco**, suggests that the former migrates over distances of at least 100 miles (161 km) but returns to fresh water during winter.

Seventy-five percent of the least **cisco** stomachs examined (n=201) contained food. Twelve least **cisco** stomachs were examined from fish taken during 1978. Of the twelve, one was empty. Following is a list of the gut contents, omitting the empty stomach:

Mysids	91%
Amphipods	45%
Dipterans (adult)	27%
Isopods	9%
Vegetation/detritus	9%

Arctic Cisco

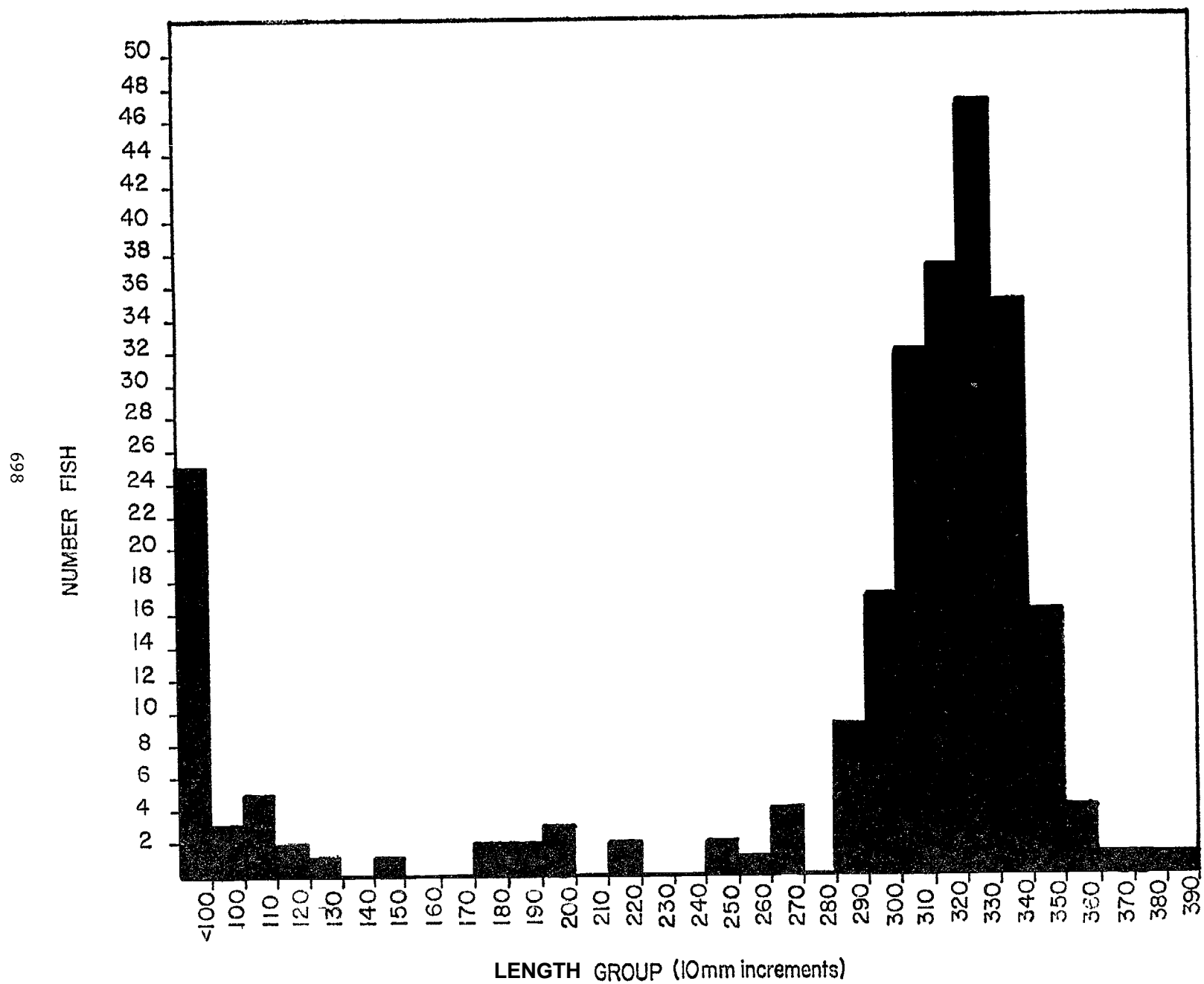
The Arctic **cisco** is distributed throughout northern Europe, Siberia and western Arctic North America. From the Gulf of Alaska north to the western Beaufort Sea, the Arctic cisco is replaced by the Bering **cisco**, C. laurettae, as described by McPhail (1966). In Alaskan waters, the Arctic **cisco** ranges from Point Barrow east to Demarcation Point. They are one of the most common and widely distributed fish found with our study area and are used by local residents in coastal subsistence fisheries as well as in small commercial fisheries at the mouth of the Colville River and near Point Barrow. Arctic cisco life history data are discussed by Craig and McCart (1976) and Hatfield, Stein *et al.* (1972) .

A total of 1,361 Arctic **cisco** was captured during 1975 and 1976. Fork lengths ranged from 62 mm to 390 mm with a mean of 285 mm (n=253). Figure 11 shows the length frequency of Arctic **cisco** captured during this study. Few individuals in the sample were greater than 350 mm. Maximum lengths are less than those reported by Berg (1948-49) for

Table 3. Age length frequency of least cisco captured during 1975 and 1976.

Length Group	Age Classes												total
	I	II	III	IV	v	VI	VII	VIII	IX	x	XI	XII	
< 100	1	1											2
100-109	1												1
110-119	4												4
120-129	2	1											3
130-139		1											1
140-149			1										1
150-159		1	1										2
160-169													0
170-179			1										1
180-189			4										4
190-199			9	3									12
200-209			11	7	1								19
210-219			3	10			1						14
220-229				6	1	1	4						12
230-239				1	4		1						6
240-249				1	1	1							3
250-259					1	3	3						7
260-269						4	4	2	3				13
270-279						3	10	2	1				16
280-289						2	17	4	5	1			29
290-299						1	4	7	5	6	2		25
300-309							1	7	15	5	3		31
310-319								3	5	11	2		21
320-329									7	4	4		15
330-339								1	4	3	1	1	10
340-349									1	7	2	2	12
350-359										2		1	3
360-369										1	1	2	4
n	8	4	30	28	8	15	45	26	46	40	15	6	271
\bar{x}	110	127	197	212	231	264	272	296	309	319	320	350	272
Range	82-125	92-150	139-210	190-240	202-250	225-290	219-285	260-345	278-340	290-353	297-360	331-364	84-364

Figure 11. Length frequency of Arctic cisco captured during 1975 and 1976.



Siberian forms, McPhail (1966) for Point Barrow and Hatfield, Stein et al. (1972) for MacKenzie River forms.

Although Arctic cisco reach a maximum age of at least XI (Hatfield, Stein et al., 1972), cisco within the study area ranged from Age I through Age IX. Immature fish of Age VI comprised 46% of the sample. An age-length frequency is presented in Table 4. As with least cisco the growth rate of Arctic cisco captured in the Beaufort Sea is lower than reported for the MacKenzie River (Hatfield, 1972) and Siberia (Berg, 1948-1949). Figure 12 shows the mean back calculated lengths of Arctic cisco from the Beaufort Sea. Arctic cisco enter the Beaufort Sea at Age I.

The female to male sex ratio of 198 Arctic cisco was 9:1. There were no sexually mature individuals in our sample. Berg (1948, 1949) states that Siberian Arctic cisco mature at Age V, however the age at maturity varied between river systems. Craig and McCart (1976) suggest that Arctic cisco from the Beaufort Sea reach maturity between ages of VII and IX, Craig and McCart (1976) further postulate that Arctic cisco only use the two largest drainages in the region, the Colville and MacKenzie rivers, as spawning areas. Arctic cisco spawn in the fall. The spawning periods and locations for the Colville River have not been identified. Either mature Arctic cisco do not range in the area of our study or they do not range as far from natal streams as do the younger age classes.

Six hundred twenty-eight Arctic cisco were tagged in Prudhoe Bay during 1976 and 21 of those were recaptured throughout the season. The first Arctic cisco was captured on June 28, and their seasonal abundance was similar to that of least cisco; the greatest number being captured during the month of August. A single individual tagged in Prudhoe Bay was recaptured at Griffin Point near Barter Island, 19 days after being tagged. Movement trends of Arctic cisco in Prudhoe Bay require further investigation. Nineteen of the 21 recaptured Arctic cisco were taken during the fall run in the Colville River.

Sixty-five percent of the Arctic cisco stomachs examined (n=153) contained food. Following is a list of the gut contents of stomachs:

Mysids	60%
Amphipods	53%
Vegetation/detritus	40%

Broad Whitefish

Broad whitefish are distributed throughout Eurasia and drainages of the Arctic Ocean. In North America, broad whitefish inhabit drainages of the Bering, Chukchi and Beaufort seas ranging as far east as Perry River. Berg (1948-49), Nikolsky (1961), Alt (1972) and Hatfield, Stein et al. (1972) have investigated the life histories of northern populations of broad whitefish. Broad whitefish in Alaskan waters support valuable commercial and subsistence fisheries.

Table 4. Age length frequency of Arctic cisco captured during 1975 and 1976.

Length Group	Age Classes									Total
	I	II	III	IV	V	VI	VII	VIII	IX	
< 100	25									25
100-109		3								3
110-119	3	2								5
120-129		2								2
130-139		1								1
140-149										
150-159			1							1
160-169										
170-179										
180-189			2							2
190-199			2							2
200-209			3							3
210-219										
220-229			1	1						2
230-239										
240-249										
250-259				2						2
260-269				1						1
270-279				1	3					4
280-289										
290-299				1		6	2			9
300-309					1	10	3	2	1	17
310-319					5	16	4	7		32
320-329					1	28	3	3	2	37
330-339					1	30	9	5	2	47
340-349						16	8	11		35

Table 4. (Cont.) Age length frequency of Arctic **cisco** captured during 1975 and 1976.

Length Group	Age Classes									total
	I	II	III	IV	v	VI	VII	VIII	IX	
350-359						7	5	4		16
360-369						3		1		4
370-379								1		1
380-389								1		1
390-399								1		1
n	28	8	9	6	11	116	34	36	5	253
\bar{x}	82	116	199	259	303	327	331	339	323	283
Range	62-115	104-131	156-220	222-290	270-335	290-365	298-355	305-390	306-331	62-390

Figure 12. Back calculated fork lengths of Arctic cisco captured in Prudhoe Bay.

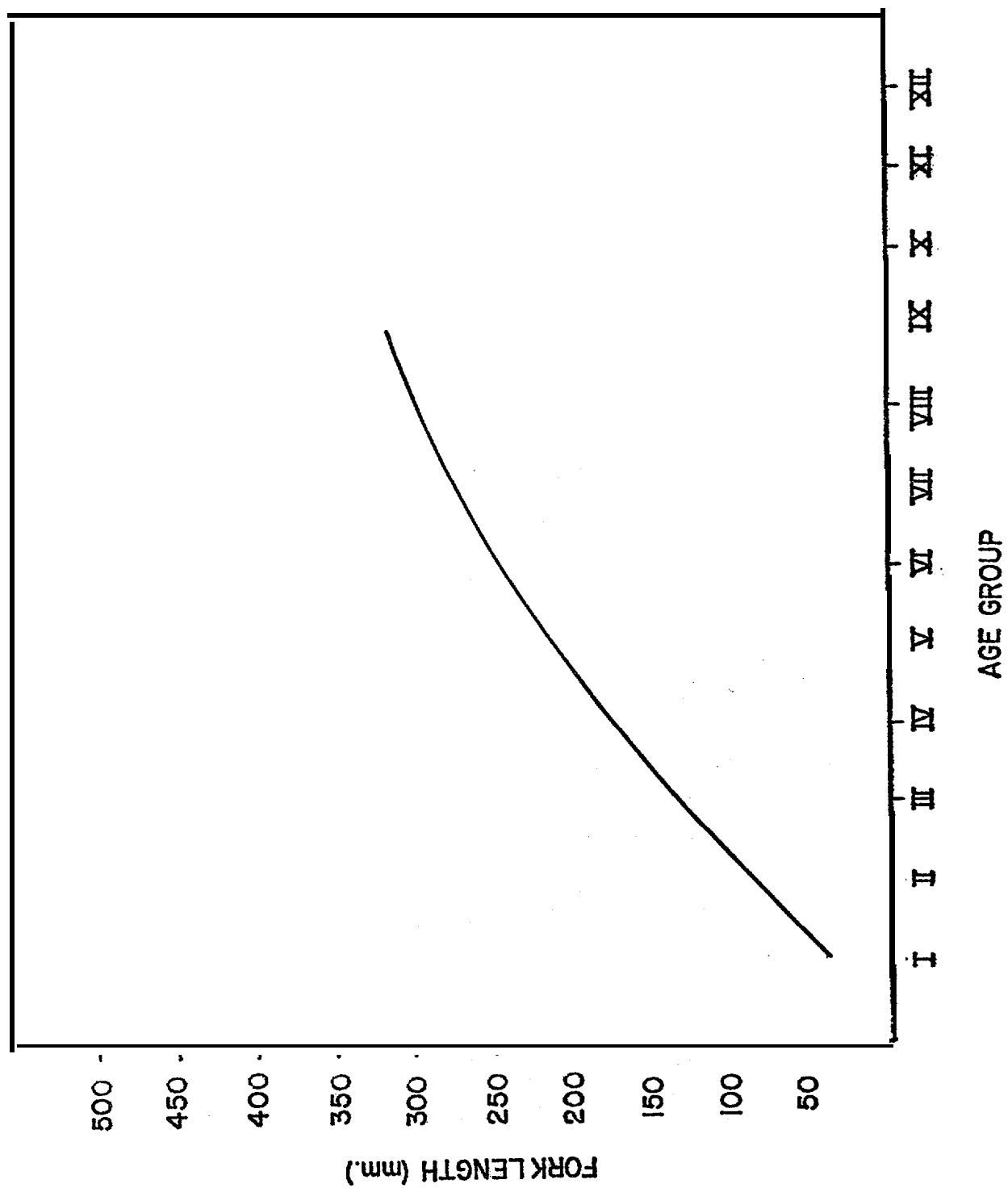


Figure 13. Back calculated fork lengths of broad whitefish taken in Prudhoe Bay and Minto Flats (Interior Alaska).

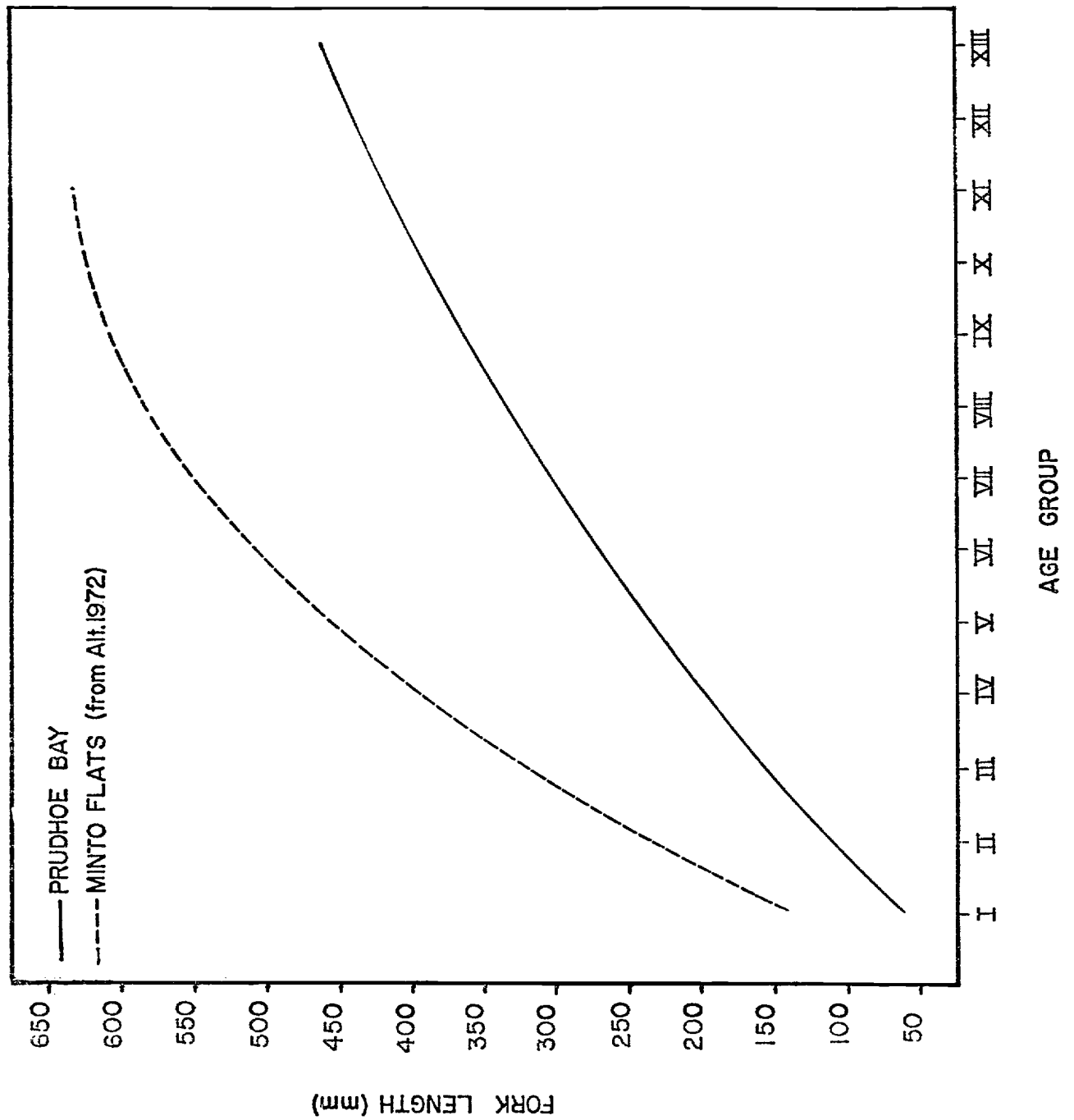
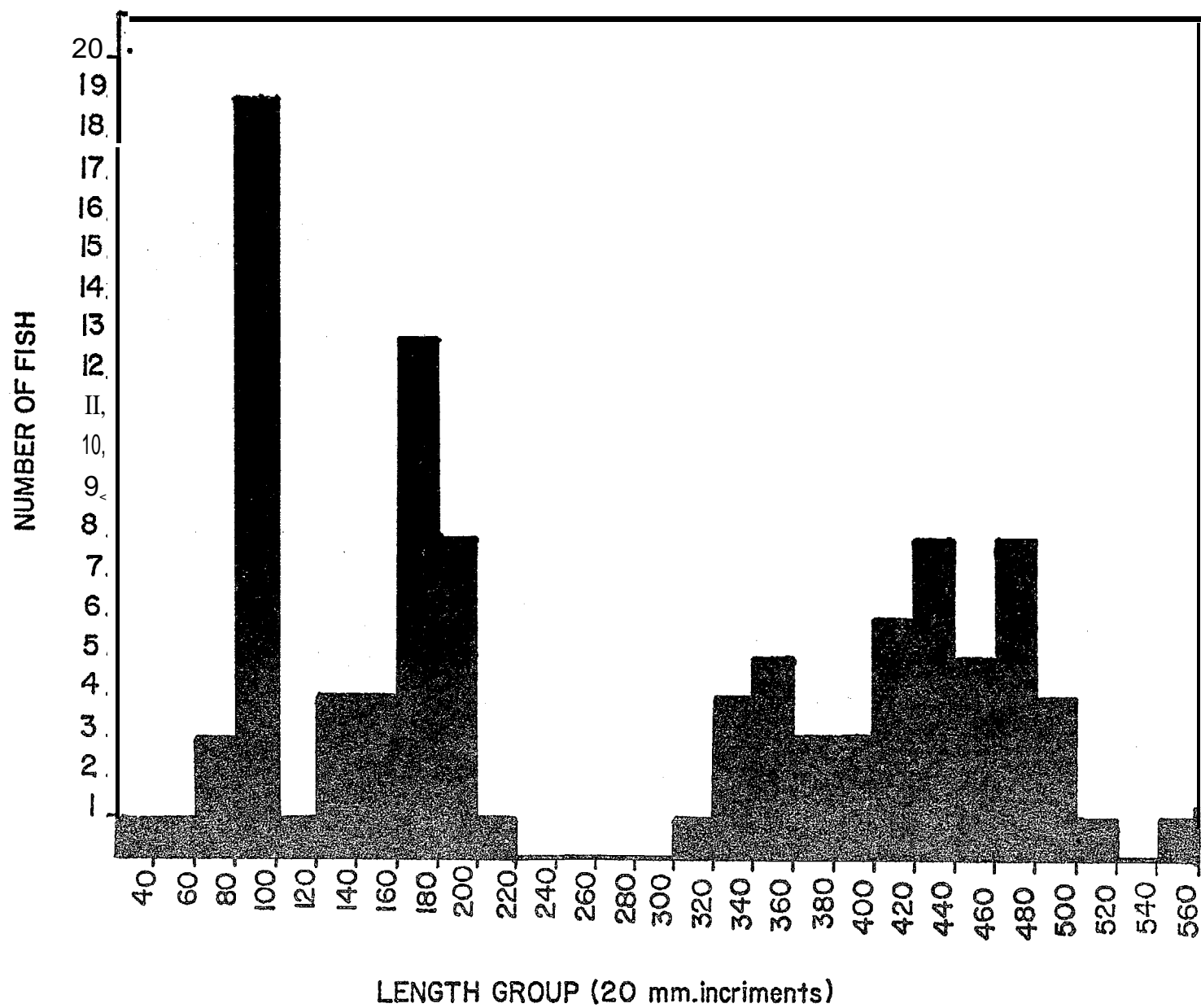


Figure 14. Length frequency of broad whitefish taken in Prudhoe Bay during 1975 and 1976.



A total of 741 broad whitefish was captured between the Colville River and the eastern margin of Foggy Bay during 1975 and 1976. Fork lengths ranged from 58 mm to 555 mm with a mean of 287 mm (n=113). Maximum lengths are considerably smaller than those reported for the MacKenzie River (Hatfield, Stein et al., 1972) and Siberia (Berg, 1948). Figure 13 compares back calculated fork lengths of broad whitefish in Prudhoe Bay and Minto Flats (Interior Alaska). The length frequency for broad whitefish is presented in Fig. 14.

Ages ranged from young-of-the-year through Age XV, however Ages IV-VII were not represented in the sample. The ratio of females to males was 0.52:1. Fifty percent of the Age IX broad whitefish were mature. Twenty-three of those fish between Ages XI and XIII had redeveloping gonads and would not spawn in the year of capture.

One hundred ninety-seven broad whitefish were tagged in Prudhoe Bay during 1976. Only one of these individuals was recaptured. Broad whitefish enter the Beaufort Sea when the larger rivers break up in early June. Broad whitefish were captured off the Sagavanirktok River delta on June 11 and were found in Prudhoe Bay on June 23. Upon entering the Beaufort Sea, broad whitefish forage along the mainland coastline, inhabiting shallow bays and lagoons. Young-of-the-year and Age I broad whitefish seldom traveled beyond the waters adjacent to the Sagavanirktok and Colville river deltas. Tagging conducted by Furniss (1975) suggests that both Colville and Sagavanirktok river stocks of broad whitefish inhabit Prudhoe Bay and other near shore waters between these two rivers during the summer months. Broad whitefish were absent from all but the western barrier islands within the study area. Adult broad whitefish re-enter the Sagavanirktok River in late August and spawn in deep pools throughout the lower reaches of the delta. In 1976, ripe broad whitefish were captured in the Sagavanirktok River during the last week of September. Large numbers of broad whitefish overwinter in deep pools within the river delta.

Forty percent of the broad whitefish stomachs contained food. The predominant food organisms were chironomid larva and amphipods. All of the spawning broad whitefish captured in the Sagavanirktok River had empty stomachs.

Humpback Whitefish

Humpback whitefish are distributed across northern North America and Arctic Siberia. It is the most widely distributed of any whitefish in Alaska. They generally range throughout mainland drainages and are less frequently found at sea. McPhail and Lindsey (1970), Hatfield, Stein et al. (1972); and Alt (1973, 1974) present life history data on northern populations of humpback whitefish. Alt (1974) considers all Alaskan humpback whitefish to be the species C. pidschian and that the allied species C. clupeaformis of the Great Lakes extends west only to British Columbia and the Yukon Territory.

A total of 170 humpback whitefish was captured during 1975 and 1976. Fork lengths range from 61 mm to 475 mm and averaged 410 mm. The length frequency of 170 humpback whitefish is presented in Fig. 15.

Ages ranged from I to XIII.. Figure 16 presents mean back calculated fork lengths for humpback whitefish and compares growth between Prudhoe Bay and the Chatanika River (Interior Alaska).

The greatest abundance of humpback whitefish was near the western border of the study area in the vicinity of the Colville River delta. One hundred forty-six humpback whitefish were tagged in Prudhoe Bay during 1976. Only two individuals were recaptured, moving westward approximately 6 miles in early August. Humpback whitefish were only sparsely distributed between the Colville and Sagavanirktok deltas.

The Colville River is undoubtedly the major contributor of humpback whitefish to the Beaufort Sea on the Alaskan Arctic Slope. Humpback whitefish spawn during the fall in the lower reaches of the Colville River and probably overwinter near the river delta.

Arctic Cod

Arctic cod are **circumpolar** in distribution. They are widespread throughout the Arctic Ocean and are usually associated with sea ice. Quast (1974) reported that densities of juvenile Arctic cod in the Chukchi Sea increased with depth but they are also known to inhabit freshened surface sea waters (salinity 10-15 ppt) and brackish coastal waters of the Beaufort Sea. Arctic cod occupy an important trophic position in the Arctic food web. They are considered the main consumer of plankton in Arctic seas (excluding coastal regions) and serve as a major food item in the diets of many species of marine **mammals**, birds and fish. They are sought for both human consumption and for animal food by coastal residents in northern Alaska. Various life history aspects of Arctic cod are discussed by Andriyashev (1964).

Arctic cod were the second most abundant marine species found in near shore waters of our study area. A total of 5,659 Arctic cod was captured during 1975 and 1976. Total lengths of Arctic cod ranged from 20 mm through 193 mm and averaged 120 mm. A length mode was observed between 110 and 129 mm corresponding to Age II individuals. The length frequency of Arctic cod captured in Prudhoe Bay is shown in Fig. 17.

Ages of Arctic cod ranged from young-of-the-year through Age III. Age II individuals comprised 52% of the sample. According to Andriyashev (1964) Arctic cod mature at Age IV (greater than 200mm total length) however no mature specimens were taken in our sample. The female to male sex ratio of 89 Arctic cod was 1.7:1.

Growth of Arctic cod captured near shore in the Beaufort Sea was slower than reported in Andriyashev (1964) for the Bering Sea and Cheshskaya Bay. The average total length at age for Arctic cod captured near shore during August is as follows: Age 0, 24 mm; Age I, 99 mm; Age II, 131 mm; Age III, 161 mm.

Figure 15. Length frequency of humpback whitedfish taken in Prudhoe Bay during 1975 and 1976.

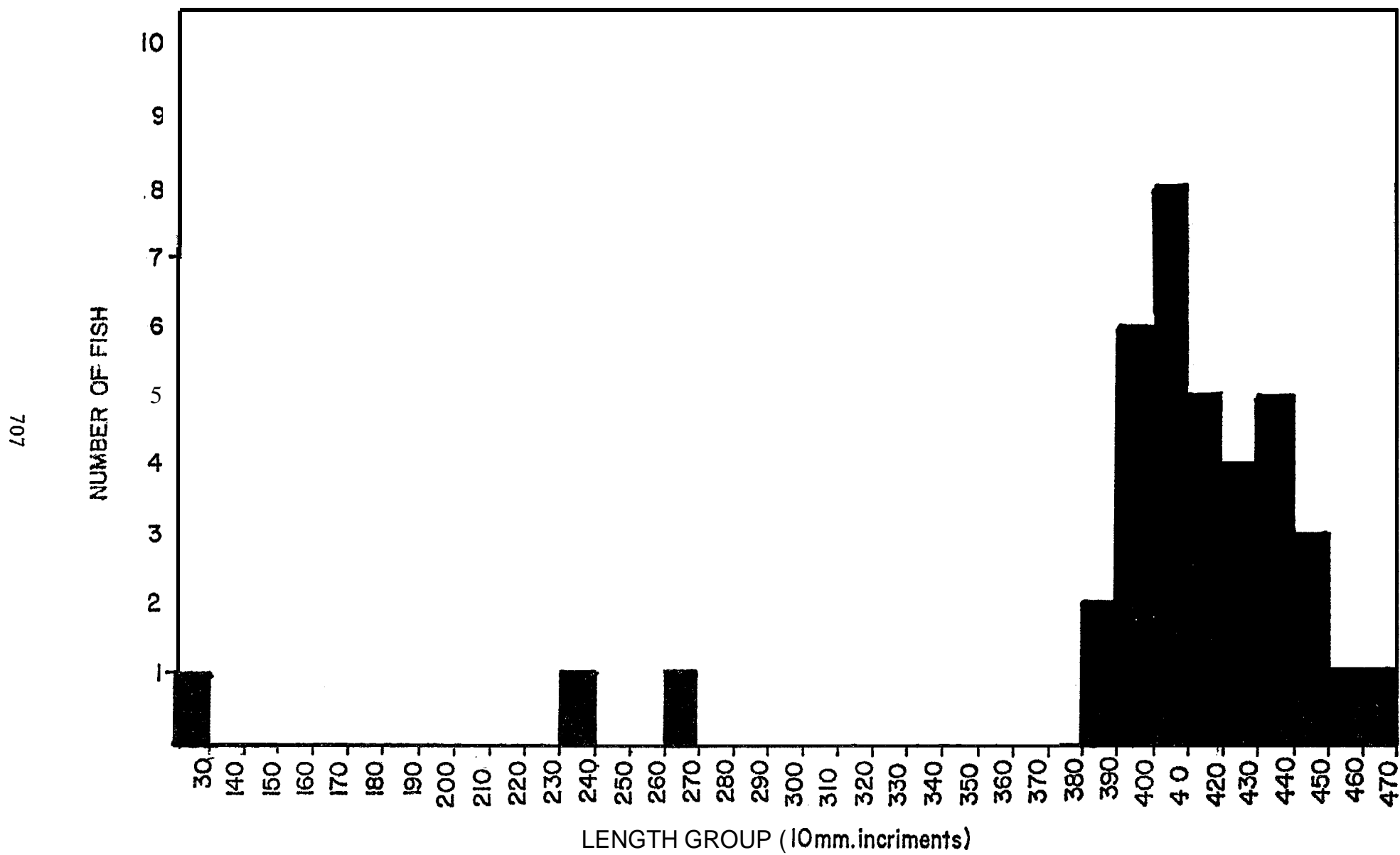


Figure 16. Back calculated fork lengths of humpback whitefish taken in Prudhoe Bay and the Chatanika River (Interior Alaska)..

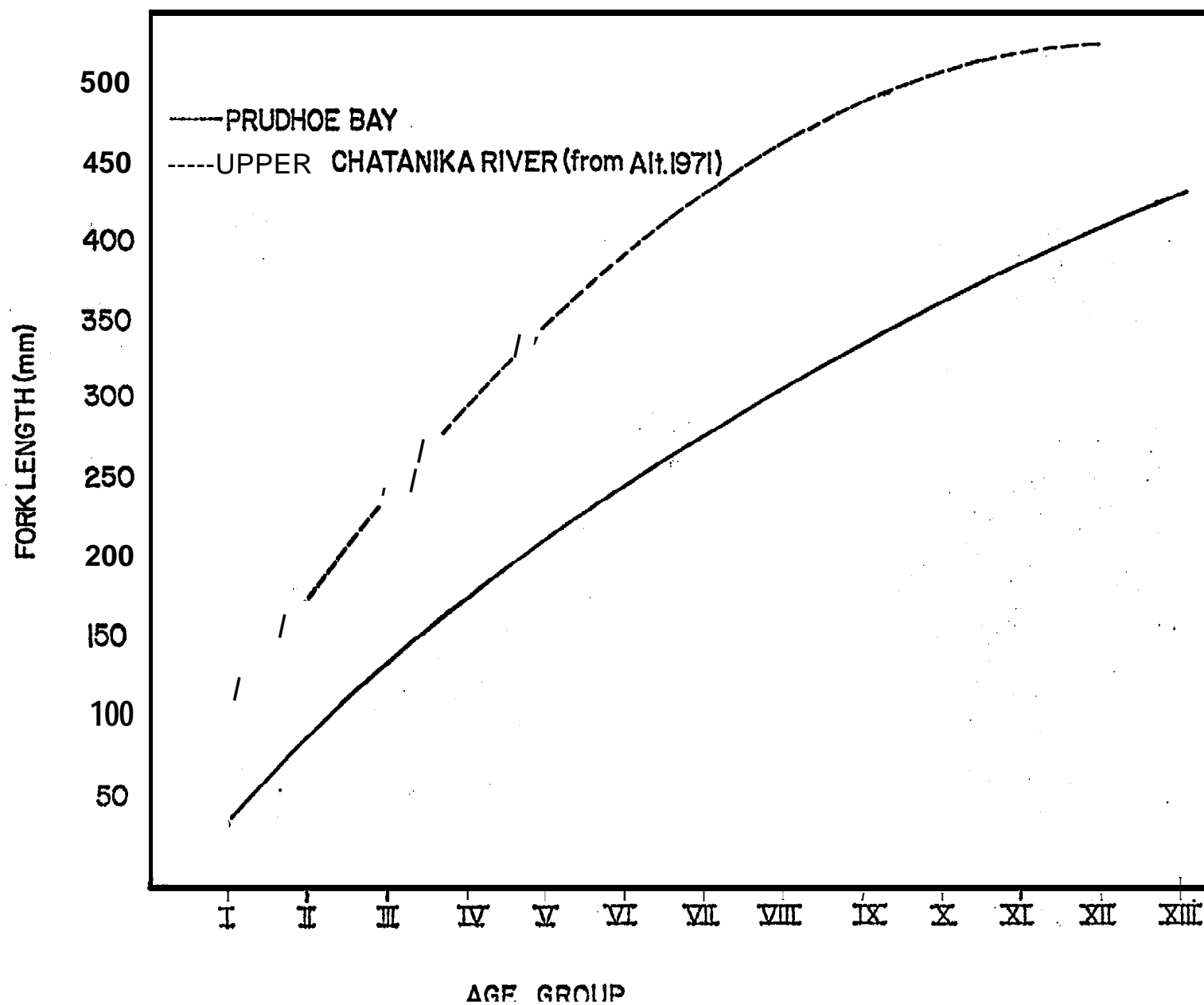
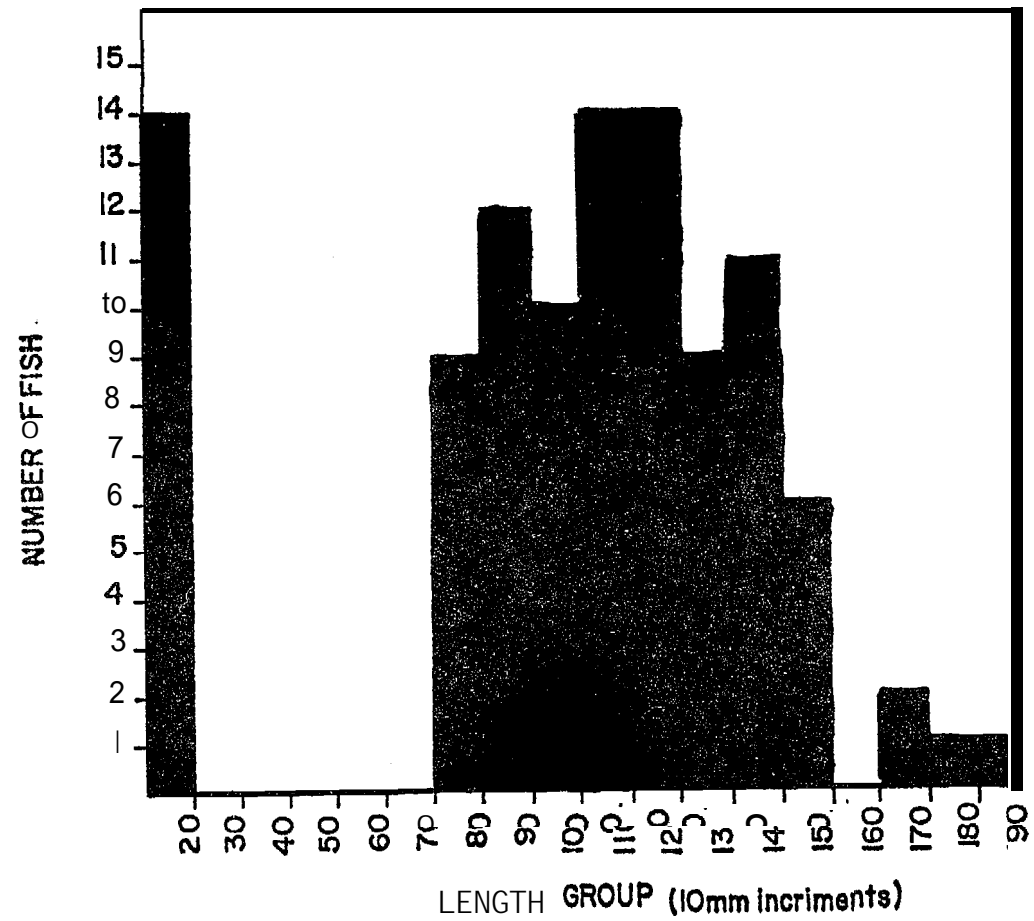


Figure 17. Length frequency of Arctic cod captured in Prudhoe Bay during 1975 and 1976.



Arctic cod were first captured in Prudhoe Bay during the second week of July. Daily catches were low for the remainder of July and first half of August then increased greatly through the second week of September. Large numbers of cod fry (corresponding to Age 0 fish above), were trawled offshore in Prudhoe Bay (2-4 m of water) during the second week of August 1975.

Arctic cod spawn near shore under the ice during January and February, however locations and timing of spawning have not been documented for the Beaufort Sea. Arctic cod eggs are the largest and fewest per female of all Gadidae and fecundity varies from 9,000 to 21,000 eggs (Andriyashev).

Arctic cod reportedly feed on phytoplankton and zooplankton including copepod eggs, nauplii, and copepods.

The examination of 12 stomachs indicated that cod feed primarily on mysids in Prudhoe Bay.

Fourhorn Sculpin

The distribution of the fourhorn sculpin is circumpolar. They are found in marine, brackish, and occasionally fresh water. The fourhorn sculpin is the most abundant marine species in our study area.

It occupies nearly all available habitats and was captured off several of the outer barrier islands, as well as in the low salinity waters of the major river deltas. Some life history aspects of fourhorn sculpin in the Beaufort Sea are discussed by Griffiths et al., (1975).

A total of 7,890 fourhorn sculpin was captured during this investigation. Total lengths ranged from 50 mm to 263 mm with a mean of 125 mm. Figure 18 shows the length frequency of fourhorn sculpin captured during 1975 and 1976.

Ages of fourhorn sculpin varied from I through VII years with the majority of fish captured in Age Classes II and III.

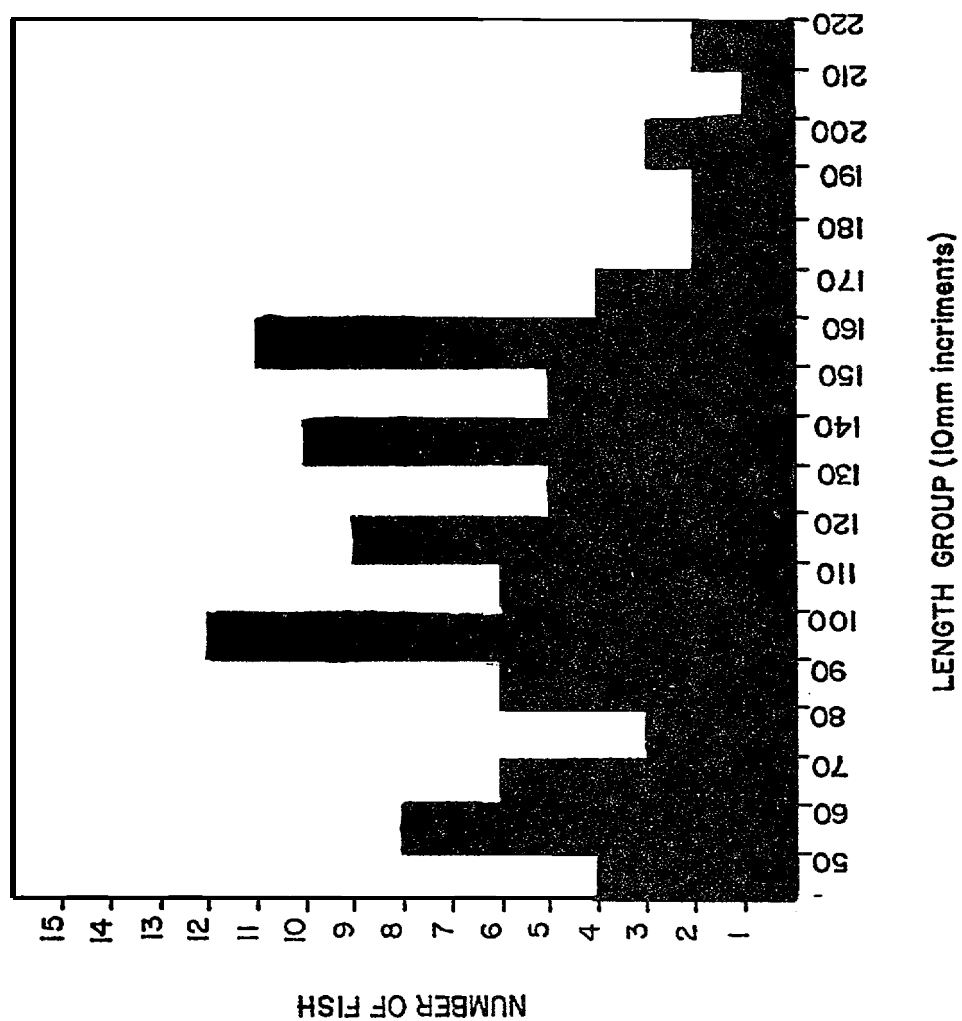
Fourhorn sculpin were the earliest marine species captured in Prudhoe Bay (June 23) and they were captured in abundance throughout the open water season.

Within the study area, fourhorn sculpin fed primarily on immature isopods, amphipods and juvenile Arctic cod.

Arctic Flounder

The Arctic flounder was the only marine flatfish taken near shore during the two years of this study. Little information is available on the life history of Arctic flounder taken in North American Arctic waters. McPhail and Lindsey (1970) delineate the worldwide distribution of Arctic flounder and Griffiths et al. (1975) examined a small sample of Arctic flounder captured in Nuneluk Lagoon, east of Barter Island.

Figure 8. Length frequency of fourhorn sculpin captured during 1975 and 1976.



Andriyashev (1964) provides other life history information for this species.

Arctic flounder were not common within the study area, however small numbers were captured throughout the open water season. Their near shore abundance was greatest near the mouth of the Colville River. Arctic flounder were captured near shore in Prudhoe Bay from the second week of July through the first week of September.

A total of 37 Arctic flounder was captured during the present study. Fork lengths ranged from 60 mm through 254 mm and averaged 191 mm ($n=31$). Figure 19 shows the length frequency of Arctic flounder captured during this study. The length distribution of Arctic flounder taken in Prudhoe Bay corresponds well with catches reported by Griffiths et al. (1975) and Andriyashev (1964).

Ages of Arctic flounder ranged from I to XII with the greatest number of fish captured at Age X. The growth rate of Arctic flounder is apparently very slow.

Sexual maturity is attained at the fourth or fifth year of life. Fecundity is 50,000-200,000 eggs and spawning takes place under the ice during January and February (Andriyashev). Mature individuals in Prudhoe Bay ranged from Age IV through Age XII. There were no Arctic flounder spawning or overwintering areas located in this study.

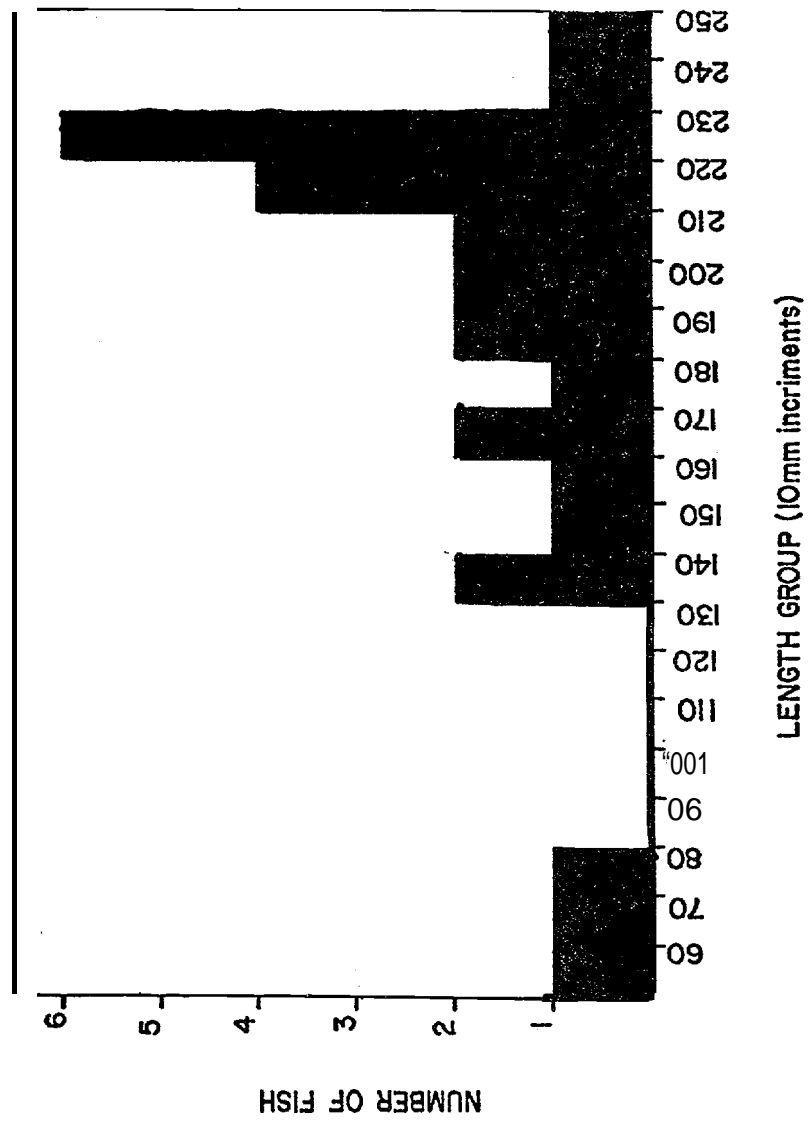
Arctic flounder reportedly feed on small fish, bivalve mollusks and small bottom invertebrates. In Prudhoe Bay, Arctic flounder feed primarily on amphipods and to a lesser extent on mysids and juvenile isopods.

Other Species

Two species of smelt (capelin and boreal smelt) were captured in low numbers throughout the study area. Of the two, capelin were the most abundant, but they were only captured during a two week period in mid-August when spawning took place within the surf along exposed gravel beaches. Young-of-the-year capelin were trawled in Prudhoe Bay during the same time period. A total of 60 capelin was captured during 1975 and 1976. Little information is available on the life history, spawning and overwintering habits of capelin. Andriyashev (1964) describes three spawning runs of capelin in the Barents Sea taking place from March through September. Near Pt. Barrow, capelin spawn in late July and August and are captured with hand nets by local residents for food. The importance of capelin in the marine trophic system is not clearly understood.

Fifty-five boreal smelt were captured during this study. They are distributed across the northern coast of Alaska and Canada and ascend the Mackenzie River as far as the Arctic Red River. During January and February, large numbers of boreal smelt are caught under the ice of the Kuk River Delta (near Wainwright, Alaska) by local residents. Boreal

Figure 19. Length frequency of Arctic flounder captured during 1975 and 1976.



smelt captured within the study area ranged from 92 mm to 251 mm with a mean of 146 mm. Ages varied from II through IX. Age III individuals comprised 64% of the catch and those individuals Aged IV and older were mature.

Saffron cod and an unidentified species of the genus Liparus were also captured in low numbers incidental to the other-marine species. Fourteen saffron cod were captured between June and September, and 71 liparids were netted during the second and third weeks of September. Young-of-the-year liparids were trawled in Prudhoe Bay during late August.

Grayling, round whitefish and ninespine sticklebacks were captured sporadically and in low numbers throughout Prudhoe Bay during 1976. Only two ninespine sticklebacks were captured in September. Fourteen immature round whitefish were captured in July and August. Forty-seven grayling were captured in Prudhoe Bay between the last of June and the middle of August 1976. Grayling in Prudhoe Bay were captured in salinities that ranged from 1 ppt to 13 ppt.

FINDINGS 1977

Fish Migrations and Timing in Prudhoe Bay

The study in 1977 concentrated on anadromous fishes in Prudhoe Bay. The primary objective was to compare the timing and movement data gathered in 1977 with that of the same time period in 1976. A secondary objective was to tag as many of these fish as possible to further identify migration patterns of these fish.

The techniques for capture and tagging were identical to those employed during the 1976 field season in Prudhoe Bay. Data gathered in 1976 indicated that the period from mid-July to mid-August was the most productive time for capturing large numbers of anadromous fish of tagging size (over 200 mm). On July 12, 1977 fyke trap stations were established on both sides of the new Prudhoe Bay causeway on the northwest corner of the bay and on the west side of the old causeway on the eastern shoreline of the bay, approximately 15 km away (Fig. 20).

Stations were checked once or twice daily and all fish captured were enumerated and the numbers recorded on catch forms. All salmonids over 200 mm in length were tagged with orange or red Floy tags and released.

Physical parameters recorded at the stations each day included air temperature, water temperature and salinity.

Ice movement forced occasional removal of traps for short periods of time and storm action occasionally raised the water level so that the traps could not be checked, or lowered the water level so that the traps were not fishing efficiently. Fyke trapping was conducted until August 14.

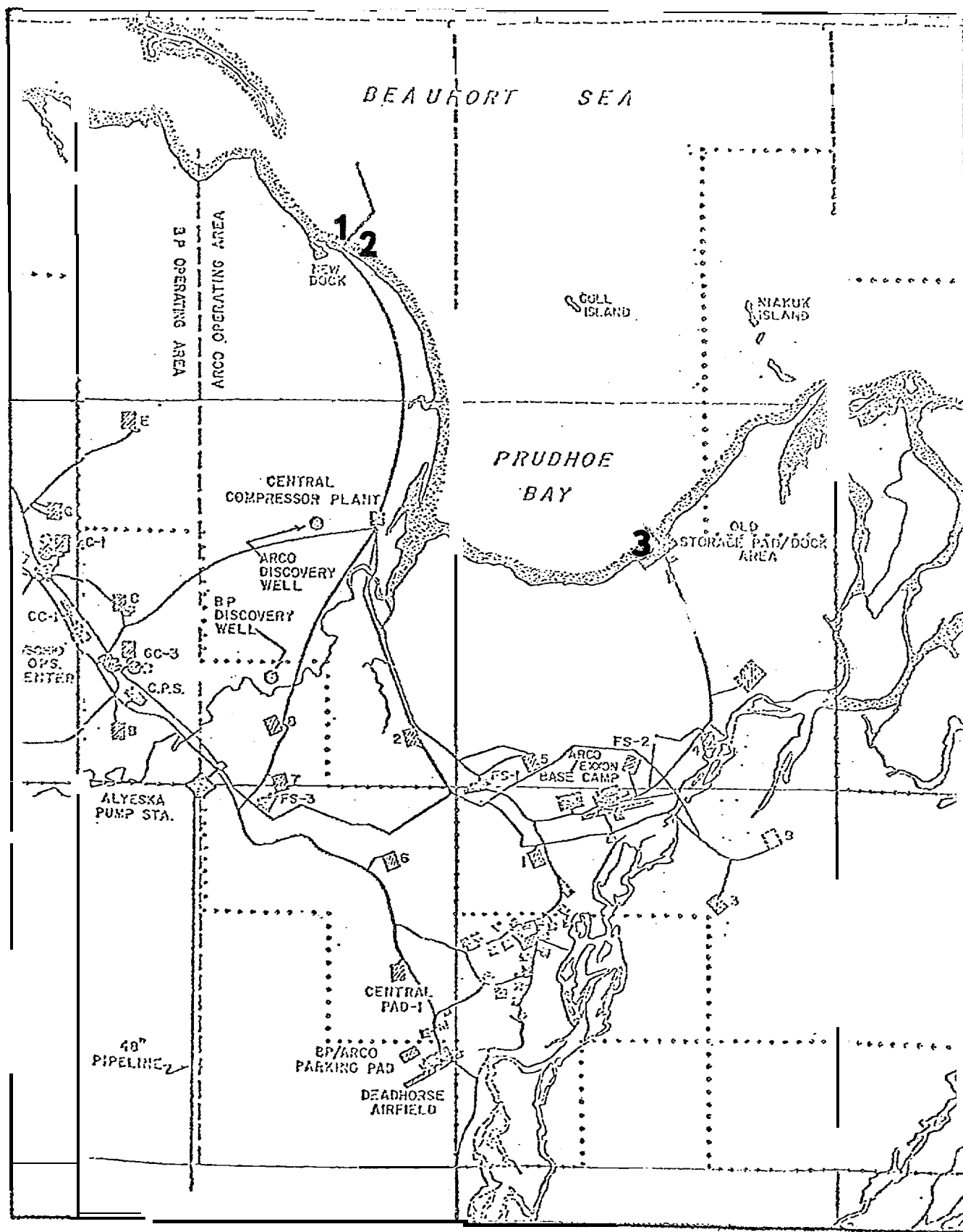


Figure 20. 1977 tagging stations in Prudhoe Bay. 1 - West New Dock
2--- East New Dock, 3 - West Old Dock

The numbers of each species captured at each station each day and the surges in numbers of fish caught were compared, where possible, to show the direction of movement.

The number of fish tagged was compared to the number of fish captured to determine the approximate percentage of fish over 200 mm in the catch. This gives us an idea of the percentage of larger, older fish in the bay

A total of 5,160 fish of all species was captured (Table 5), including 2,324 fish of the target species (Arctic char, Arctic cisco, broad whitefish, humpback whitefish, and least cisco). Nine hundred forty-one of these fish were tagged (Table 6). This compares with 6,354 anadromous fish captured during the same time period of 1976, of which 3,943 were tagged.

Water temperatures were slightly higher in 1977 than they were during the same period in 1976.

Salinities were significantly higher in 1977 than in 1976. The average salinity for the areas where capture stations were operated was as high as the highest salinity recorded for those areas during the equivalent period in 1976 (Table 7 and Appendix I).

High salinities in 1977 may have accounted for the lower numbers of all anadromous fish in the bay. Greater numbers of anadromous fish, especially Arctic char and least cisco, appeared to move into or through the bay in response to short term decreases in salinity. This was especially apparent at the West Old Dock and East New Dock capture stations (Appendix I).

This contrasts with results obtained in 1976, when, during periods of moderate or low salinity, no correlation could be made between fish abundance and increases or decreases in salinity. It is probable that the fish were remaining in areas of fresher water, such as river deltas, during the periods of high salinity in 1977.

Four of the fish tagged during the 1977 season were recaptured. Three of these (two least cisco and one char) were captured in the same locations where they were tagged from 2 to 8 days later and little could be learned from them. The fourth, a least cisco was recaptured by an Eskimo fisherman at Griffin Point, 241 km (150 mi) to the east, 20 days later.

Four Arctic char tagged in 1976 in Prudhoe Bay were recaptured in Prudhoe Bay in 1977. Their time out ranged from 342 days to 367 days and averaged 357 days.

Ten least cisco tagged in 1976 were recaptured in 1977. Their time out ranged from 364 days to 397 days and averaged 377 days. Two fish that were tagged and released consecutively in July of 1976 were recaptured in the same trap 370 days later. Two other least cisco tagged out of

Table 5. Fish species and number captured during the 1977 summer season at Prudhoe Bay.

Common Name	Scientific Name	OCS Species Code	Number Captured
Arctic char	<u>Salvelinus alpinus</u>	7904010402	903
Grayling	<u>Thymallus arcticus</u>	7904010701	3
Humpback whitefish	<u>Coregonus pidschian</u>	7904010104	16
Broad whitefish	<u>C. nasus</u>	7904010103	89
Least cisco	<u>C. sardinella</u>	7904010105	1,078
Arctic cisco	<u>C. autumnalis</u>	7904010101	238
Arctic cod	<u>Boregadus saida</u>	7909020201	647
Fourhorn sculpin	<u>Myoxocephalus quadricornis</u>	7915042206	2,171
Arctic flounder	<u>Liopsetta glacialis</u>	7917021101	7
Boreal smelt	<u>Osmerus mordax</u>	7904020302	7
Pink salmon	<u>Oncorhynchus gorbuscha</u>	8755010201	<u>1</u>
Total			5,160

Table 6. Comparison of numbers of **anadromous** fish captured and tagged during the period from July 13 to August 14 in 1976 and 1977. Percentages of total fish captured that were tagged are in parentheses.

Species	Number Captured		Number Tagged*	
	1976	1977	1976	1977
Arctic char	2,103	903	467 (22%)	232 (26%)
Arctic cisco	751	238	461 (61%)	139 (58%)
Broad whitefish	271	89	151 (56%)	34 (38%)
Humpback whitefish	132	16	124 (94%)	15 (94%)
Least cisco	<u>3,097</u>	<u>1,078</u>	<u>2,740</u> (88%)	521 (48%)
Totals	6,354	2,324	3,943	941

* These numbers correspond to the numbers of fish with a fork length of 200 mm or greater.

Table 7. Average salinity and water temperature of Prudhoe Bay for period of July 13 to August 15, 1976 and 1977.*

Area	Average Temperature, °C		Average Salinity, PPT	
	1976	1977	1976	1977
West Old Dock	8.0 (n=32)	9.0 (n=29)	5.0 (n=29)	14.0 (n=29)
East New Dock	7.5 (n=19)	8.0 (n=21)	11.0 (n=15)	15.0 (n=21)
West New Dock	5.5 (n=29)	6.0 (n=29)	6.5 (n=24)	22.0 (n=28)
Average all areas	7.0	8.5	7.5	17.0
Range all areas	2 - 14	2 - 17	0 - 17	2 - 32

* Derived from Appendix I.

the same trap the same day in 1976 were recaptured in the same trap in 1977 a day apart.

Movement, direction, and timing were about the same in 1977 for those species for which enough fish were captured to make a determination.

Arctic char, Arctic cisco and least cisco all exhibited approximately the same movement patterns in 1977 that they did during the same time period in 1976.

Arctic char showed eastward movement in late July and early to mid-August, with increasing percentages of larger, older fish in August.

There was a strong eastward movement of least cisco in late July and early August. Over half of these fish were larger, older fish. There was a westward surge of small fish in mid-August.

The only significant tag return, as of October 1977, was the least cisco that swam from Prudhoe Bay to Griffin Point. In 1976 during the same time period a least cisco took 21 days to do the same thing. This indicates that a portion of the least cisco population either ranges far to the east or that some of the Prudhoe Bay fish are of eastern origin. The 1976 results show the majority of least cisco in Prudhoe Bay were of Colville River origin.

The phenomenon of consecutively tagged least cisco being recaptured at the same time at the same location after a long period of time was observed several times and indicates strong schooling behavior among least cisco.

Arctic char and least cisco both started their late summer movement (char to the Sagavanirktok River and least cisco to the Colville River) slightly earlier than in 1976, probably in response to the higher salinity.

As in 1976, Arctic cisco movements were unclear. There were apparently small magnitude eastward movements in mid-July. Fifty-eight percent of the catch was composed of larger, older fish (fork length > 200 mm).

Broad whitefish and humpback whitefish were present in eastern Prudhoe Bay in small numbers in the last part of July and early August. The majority of broad and humpback whitefish may have remained off the river deltas all summer.

CONCLUSIONS

Species diversity of fish inhabiting the nearshore waters of the Beaufort Sea between Harrison Bay and Brownlow Point is low.

Freshwater and anadromous species are more abundant than marine species within the study area during the open water season.

The density of both **anadromous** and marine species is greatest she-reward of the 2 meter depth during the open water season.

The numbers of **anadromous** fish present in Prudhoe Bay may vary considerably from year to year.

Arctic fish are **slow** growing and late maturing and several species may only spawn in alternate years.

Stomach analysis indicates that fish utilizing the nearshore waters of the study area are opportunistic feeders, preying on a variety of marine epibenthic organisms, as well as fresh water invertebrates, aerial insects and other fish. Thus, a large scale reduction in invertebrate fauna may have a profound effect on the fishery.

The larger rivers draining into the study area serve as overwintering and spawning habitat as well as important migration corridors for **anadromous** fish utilizing the Beaufort Sea for the brief open water season.

Overwintering and fall spawning areas within river deltas are extremely sensitive to disruption due **to** the concentrated number of fish that are restricted to **small** pockets of under-ice water.

Large-scale gravel mining in river deltas can disrupt their hydrologic regime, thus affecting the availability of fall spawning and **overwinter-**ing habitat.

Human use of fish resources within the study area is low, however sport fishing has been steadily increasing since the advent of North Slope oil development.

Data from 1974 through 1977 have shown that timing and patterns of fish movements in the bay are consistent and can probably be expected to occur similarity in future years.

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APPENDIX I

Temperature, Salinity and **Anadromous** Fish Captured
in Prudhoe Bay, 1977

Area: West Old Dock

Period: July, August 1977

Date	Temp. °c	Salinity ppt	Arctic Char	Arctic Cisco	Least Cisco	Broad Whitefish	Humpback Whitefish
7/13	7.0	3.0	9	1	0	0	0
7/14	6.5	3.5	14	1	3	0	1
7/15	7.0	3.0	25	1	19	0	0
7/16	17.0	4.5	32	4	3	0	0
7/17	6.0	6.0	29	0	8	0	0
7/18			43	2	10	6	0
7/19	7.0	5.0	70	10	3	3	1
7/20	10.0	16.0	9	2	5	1	0
7/21	8.0	13.0	20	2	4	2	0
7/22	7.0	19.0	6	0	1	2	0
7/23	7.0	17.5	5	0	0	2	0
7/24	7.0	15.0			DID NOT FISH		
7/25	8.0	8.0	3	0	0	0	0
7/26	6.0	19.0	12	0	7	1	0
7/27	8.0	14.0	4	0	3	1	0
7/28	11.0	15.0	6	0	10	7	0
7/29							
7/30'	11.0	17.0	6	4	28	11	0
7/31	11.0	21.0	3	0	2	0	0
8/1	13.0	19.0	16	0	7	0	0
8/2	12.0	21.0	10	0	3	0	1
8/3	14.0	17.0	12	0	2	10	0
8/4	10.0	22.0	1	0	1	1	0
8/5	11.0	20.0	3	0	0	1	0
8/6	9.0	22.0	1	0	1	2	0
8/7	9.0	22.0	1	0	2	0	0
8/8	6.0	13.0	2	30	0	20	0
8/9"							
8/10							
8/11	6.0	12.0					
8/12	7.0	13.0					
8/13	5.0	13.0					
8/14	8.0	12.0	0	0	7	0	0

* Fish captured on 7/30 are two day totals.

**8/9 through 8/14 trap did not produce due to low water,

Area: East New Dock

Period: July-August, 1977

Date	Temp. "c	Salinity ppt	Arctic Char	Arctic Cisco	Least Cisco	Broad Whitefish	Humpback Whitefish
7/13							
7/14							
7/15	4.0	2.0	5	0	0	0	0
7/16'							
7/17							
7/18	2.0	5.5					
7/19							
7/20							
7/21							
7/22							
7/23							
7/24			0	0	2	0	0
7/25	6.0	5.0	10	4	106	0	0
7/26	6.0	11.0	6	1	26	0	1
7/27	7.0	8.5	8	0	7	2	3
7/28	8.0	19.0	7	2	29	0	1
7/29	11.0	19.0	5	0	2	0	0
7/30	11.0	21.0	5	0	1	1	2
7/31	10.0	14.0	22	0	10	1	0
8/1	10.0	12.0	28	0	12	0	0
8/2	11.0	15.5	24	0	6	0	0
8/3	11.0	24.0	3	0	0	0	0
8/4	11.0	22.0	1	0	1	0	1
8/5	10.0	19.0		0			
8/6	10.0	19.5	0	0		0	0
8/7**	5.0	27.0	19	0	14	1	2
8/8	7.0	19.0	0	0	3	0	0
8/9					DID NOT FISH		
8/10					DID NOT FISH		
8/11	5.0	12.0					
8/12	7.0	12.0	2	2	8	0	0
8/13	6.0	12.0	4	25	57	1	0
8/14	7.0	11.0	2	8	23	1	0

* Did not fish due to ice 7/16 through 7/23.

**Fish captured on 8/7 are totals of 8/5, 8/6 and 8/7.

Station 01 - 100 yards west of West Dock

Area: West New Dock

Period: July-August, 1977

Date	Temp. 'C	Salinity ppt	Arctic Char	Arctic Cisco	Least Cisco	Broad Whitefish	Humpback Whitefish
7/13	3.0	2.0					
7/14	5.0	4.0	32	9	4	1	1
7/15	2.5	3.0	1	0	0	0	0
7/16	3.0	7.0		1	11		
7/17*							
7/18							
7/19	2.0	20.0					
7/20	8.0	24.5					
7/21	9.0	28.5					
7/22	6.0	15.5	5	4	27	0	0
7/23"	6.0	23.0	7	3	44	1	
7/24							
7/25	3.0	30.0					
7/26	4.0	32.0					
7/27	6.0	26.0					
7/28	6.0	26.0					
7/29	9.0						
7/30	9.0	26.0					
7/31	8.0	26.5					
8/1	6.0	29.0					
8/2	6.0	18.5					
8/3	9*0	26.5					
8/4	9.0	28.0					
8/5	5.0	30.0					
8/6	5.0	31.0					
8/7	7.0	23.0					
8/8	6.0	27.0					
8/9	5.0	19.0					
8/10	6.0	20.0					
8/11							
8/12	6.0	23.0					
8/13	6.0	26.0					
8/14	5.0	29.0					

* Did not fish 7/17 through 7/21.

**Capture station not operated after 7/23

Station 02 - West New Dock at shoreline

Area: West New Dock

Period: July-August, 1977

Date	Temp. 'C	Salinity ppt	Arctic Char	Arctic Cisco	Least Cisco	Broad Whitefish	Humpback Whitefish
7/13	3.0	2.0	2	0	0	1	0
7/14	5.0	4.0	9	1	0	0	0
7/15'	2.5	3.0					
7/16	3.0	7.0					
7/17							
7/18							
7/19	2.0	20.0					
7/20	8.0	24.5	0	0	0	0	0
7/21	9.0	28.5	0	0	4	0	0
7/22	6.0	15.5	5	0	12	1	0
7/23	6.0	23.0	3	2	27	1	1
7/24			2	0	8	0	0
7/25	3.0	30.0	12	0	14	1	0
7/26	4.0	32.0	1	0	1	0	0
7/27	6.0	26.0	1	0	2	0	0
7/28	6.0	26.0	11	1	15	0	0
7/29	9.0		3	10	9	0	0
7/30	9.0	26.0	4	0	5	0	0
7/31	8.0	26.5	2	1	4	0	0
8/1	6.0	29.0	2	0	1	0	0
8/2	6.0	18.5	1	1	0	0	0
8/3	9.0	26.5	1	0	1	0	0
8/4	9.0	28.0	2	0	2	0	0
8/5	5.0	30.0	0	0	0	1	0
8/6	5.0	31.0	0	0	2	0	0
8/7	7.0	23.0	0	1	4	0	0
8/8	6.0	27.0	2	0	0	0	0
8/9	5.0	19.0	2	0	0	0	0
8/10	6.0	20.0	15	0	0	0	0
8/11					DID NOT FISH		
8/12	6.0	23.0	1	1	0	0	0
8/13	6.0	26.0	1	1	1	0	0
8/14	5.0	29.0	6	1	1	0	0

* Did not fish 7/15 through 7/19 due to ice.

Station 03 - 1/4 mile on causeway

Area: West New Dock

Period: July-August, 1977

Date	Temp. °c	Salinity ppt	Arctic Char	Arctic Cisco	Least Cisco	Broad Whitefish	Humpback Whitefish
7/13	3.0	2.0					
7/14	5.0	4.0	3	0	1	0	0
7/15	2.5	3.0			DID NOT FISH		
7/16	3.0	7.0	1	1	0	0	0
7/17*							
7/18							
7/19	2.0	20.0					
7/20	8.0	24.5					
7/21	9.0	28.5					
7/22	6.0	15.5					
7/23	6.0	23.0					
7/24			11	9	119	2	1
7/25	3.0	30.0	16	4	144	0	0
7/26	4.0	32.0	5	2	13	0	0
7/27	6.0	26.0	1	0	14	0	0
7/28	6.0	26.0	98	8	28	0	0
7/29	9.0		18	6	34	0	0
7/30	9.0	26.0	8	1	32	0	0
7/31	8.0	26.5	2	0	4	0	0
8/1	6.0	29.0	4	1	7	0	0
8/2	6.0	18.5	2	1	1	0	0
8/3	9.0	26.5	10	3	5	0	1
8/4	9.0	28.0	11	0	3	1	0
8/5	5.0	30.0	5	6	6	0	0
8/6	5.0	31.0	2	0	2	0	0
8/7	7.0	23.0					
8/8**	6.0	27.0	22	3	10	0	0
8/9	5.0	19.0	13	8	7	0	0
8/10	6.0	20.0			DID NOT FISH		
8/11					DID NOT FISH		
8/12	6.0	23.0	4	1	1	3	
8/13	6.0	26.0	1	4	5		
8/14	5.0	29.0	17	0	4	0	0

* 7/17 through 7/23 did not fish

**Fish captured on 8/8 are two day totals

**PRELIMINARY OBSERVATIONS ON THE DISTRIBUTION
ABUNDANCE AND FOOD HABITS OF SOME
NEARSHORE FISHES IN THE NORTHEASTERN
GULF OF ALASKA**

Research Unit 542

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FEBRUARY 18, 1978

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SUMMARY

REFERENCES

ABSTRACT

The marine fishes are an important component of the inshore fauna of the Gulf of Alaska. Direct observations of fishes living in both exposed and protected habitats of the north Gulf Coast/Prince William Sound region were made while diving from 1974-77. A total of 44 species of fish were observed in these shallow water habitats. Six species were previously unreported in these waters, and therefore represent northern range extensions in the Eastern Pacific. Five hundred and ninety specimens were collected and examined for food items; the foraging habits varied considerably depending on the habitat and the species of fish. Dietary trends were identified, important prey of the bottom feeders included amphipods, isopods, crabs, snails, mussels and brittle stars. Trophic interaction or links in the food web between the fishes and their prey are also presented.

Numerical data was also collected on relative abundance and occurrence in the nearshore zone during August, 1977. In all, **1410 square meters of sea floor were examined quantitatively at Schooner Rock, Hinchinbrook Entrance and Danger Island, Montague Strait.** The numerical dominants in the band transects during daylight hours were black rockfish (Sebastes melanops); china rockfish (Sebastes nebulosus); kelp greenling (Hexagrammosdecagrammus); lingcod (Ophiodon elongatus) and alaskan ronquil (Bathymaster caeruleofasciatus). Fishes that were common in more protected locations during summer included the pacific tomcod (Microgadus proximus); pink salmon (Oncorhynchus gorbuscha), whitespotted greenling

(Hexagrammos stelleri), and great sculpin (Myoxocephalus spp.).

Descriptions of major habitat types, and summer distributions of inshore pelagic and **demersal** species are presented in relation to substrate type, depth and vegetation. The emphasis was placed on the characteristic or conspicuous **fishes that were believed to be either numerical or functional dominants** in the nearshore system.

INTRODUCTION

The present report deals with the **marine** fishes of the north-eastern Gulf of Alaska. More specifically, the **teleostean** fishes that typically **inhabit** the inshore zone from the **intertidal/subtidal fringe** out to depths of around -30 meters. The nearshore fish assemblages of southern Alaska are for the most part **poorly understood**. Most of the **information is** at best, only fragmentary, or based on studies from other areas of the north Pacific (see Isakson, Simenstad and Burgner 1971; Simenstad and Nakatani 1977, etc.). For example, "even though there are more than 50 **scorpaenids (rockfishes)** endemic to the Pacific Coast of North America, the food habits of only a few are known" (Prince and Gotshall, 1976). Reproductive and **early** life history studies of several species of **rockfish** have been conducted by Westrheim (1975) off British Columbia and southeastern Alaska, however, most of the **samples** were obtained offshore. Therefore, until more **is** known about the habits of the inshore fishes of the Pacific rim, these studies will provide only a frame of reference for future work.

Still, the **problem** remains that the nearshore fishes and their respective habitats are most certainly vulnerable to disturbances and perturbations associated with OCS development in the Gulf of Alaska. It became apparent from the onset that a different kind of sampling program was needed in order to adequately describe these shallow water assemblages. For the most part, the use of conventional biological **sampling** gear such as grabs, trawls and nets is severely restricted in shoal areas

that are dominated by rocky, irregular substrata and dense vegetation. To this end, we relied on another scientific approach - one that involved diving **in which** direct observations and the **acquisition** of data is obtained simultaneously. Examples of this in situ approach can be obtained by examining the **pioneer** works of **Limbaugh** (1955) who studied the fishes of the southern **California** kelp beds, to more recent studies by **Hobson and Chess (1976) who described the interactions of fishes and their major** prey species off Santa Catalina Island. The contribution that has been made by these and other diver-biologists over the **past** 2 decades are broad based, and certainly **goes** beyond the expectations of most investigators' **engaged** in marine research.

This study was funded by NOAA/OCSEAP under the auspices of the environmental assessment of the Alaska Continental Shelf. The initial intent of this work was to synthesize unpublished **field** notes on certain fishes of the northeastern Gulf of Alaska (**NEGOA**), and to augment these data with a summer field survey during 1977. **This** investigation by design **is** admittedly limited in scope, and what is needed now is an intense exploration which would go beyond **these** observations, and adequately describe the nearshore fish assemblages and the role(s) of the key species in the natural system.

SAMPLING METHODS

Direct observations were made while scuba diving at depths from MLLW to 32.0 meters below the sea surface. The **diving** observations were conducted during daylight hours from 0800 to 1900 hours. Several types of quantitative information were collected about the characteristic or conspicuous fishes that were present in each location. Included were estimates of fish density (number of specimens per meter²) which were usually obtained from band transects of **varying** dimension. The transect lines were placed at both predetermined and haphazard (unbiased) locations in the subtidal zone, and were usually run along a specific **depth** contour. The lines were occasionally left on the sea floor between dives, in order to check sample error, and to recount after an elapsed time interval of 1-2 hours. Replicated 0.25 M² quadrats were also placed in a random manner, or stratified in such a way that a particular habitat or micro-habitat was sampled in the sublittoral zone.

Samples of inshore fishes were obtained during 1974-77, from the protected waters of Port Valdez to exposed locations in the northeastern Gulf of Alaska. Most of the specimens that were taken for food habits were collected with spears and mesh bags. The remainder were collected with either a variable mesh, monofilament gill net or were taken by hook and line. All specimens were measured to the nearest centimeter, standard length. The sex, gonad condition and weight (grams) was recorded for specimens obtained during August 1977. Stomachs were extracted after capture and either examined fresh under dissecting microscope, or preserved

for future identification and analysis. Some of the fishes were sent to Dr. Robert Lavenberg, Curator **of Fishes**, Los Angeles County Museum of Natural History, for taxonomic verification and were subsequently placed into the LACM fish collection.

In addition to the numerical information, species-specific interactions or natural history phenomena involving feeding, reproduction area/or spatial distribution were recorded in situ. These methods assisted in describing conditions at each study site and permitted examination of the similarities or differences between study locations.

DESCRIPTION OF THE MAJOR STUDY SITES

The summer (1977) field survey was conducted in two key locations: (1) the ocean entrance to Montague Strait off Danger Island, and (2) the west side of **Hinchinbrook** Entrance at Schooner Rock and **Zaikof** Point (Figure 1). Both areas are known to be important centers of fish activity, and have been targeted as possible sites of oil and gas impingement because of oceanic circulation patterns and tanker traffic in the northern Gulf of Alaska. **The waters of Prince William Sound are for the most part protected from deep sea swells and ocean surf originating in the Gulf.** However, the major areas we chose to investigate were more exposed and as such represent fish assemblages that are more typical of the outer coast.

Danger Island

Danger Island is situated on the southwest edge of Prince William Sound. The site is strategically positioned between Latouche Passage on the north and Montague Strait to the south (Figure 2). These waterways are major arteries that connect the Sound to the Gulf of Alaska. An extensive reef extends for approximately 4 km off Latouche **Point and eventually** merges with Danger Island. The entire reef **complex is exposed** to westerly ocean swells, and a great deal of drift accumulates **along the beachlines**, especially during spring and fall. Tidal currents are typically moderate to weak in the lee of **Latouche** Island, however, further offshore where the water mass is not deflected by land, tidal currents can exceed 3 nautical miles per hour.

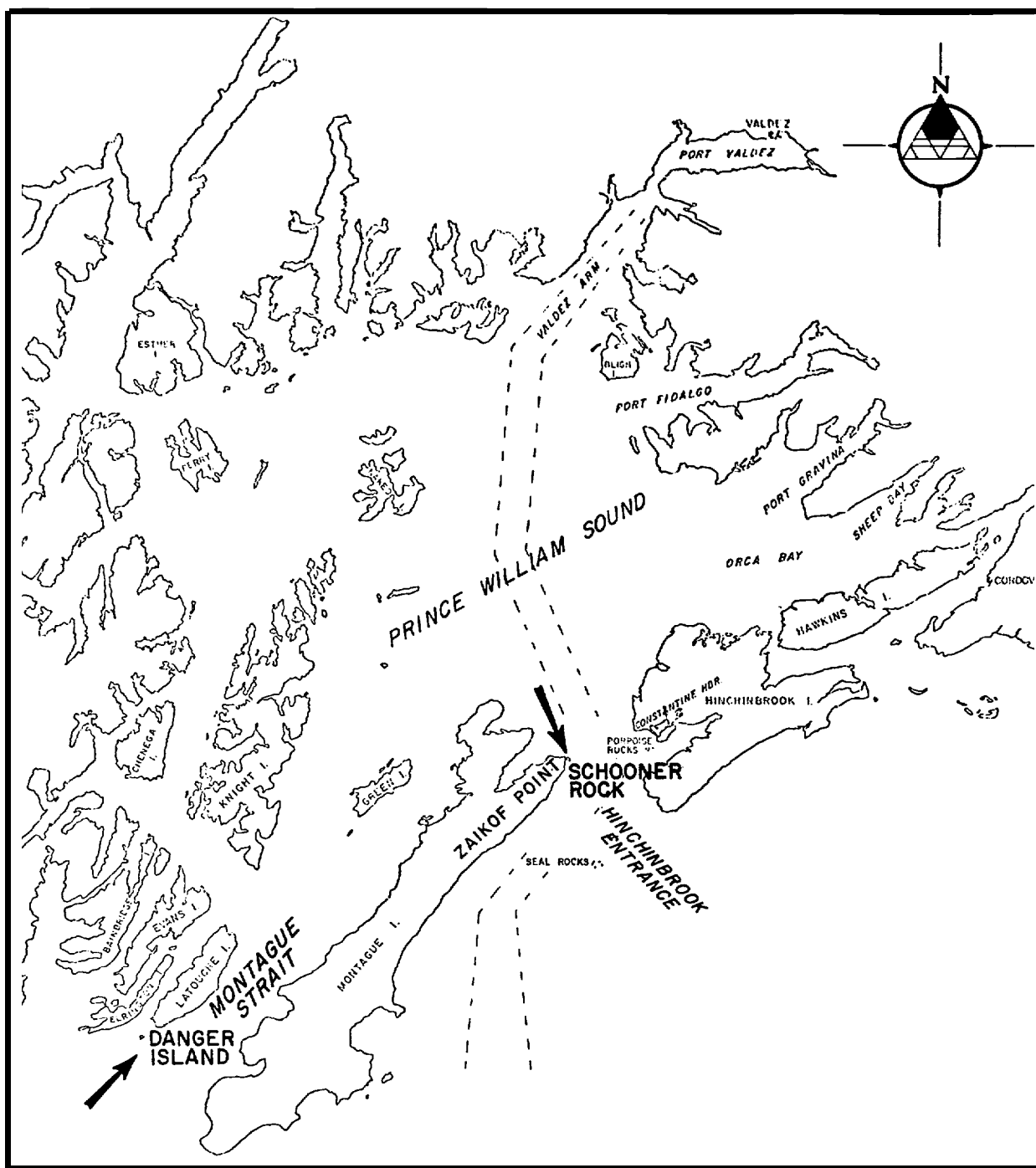
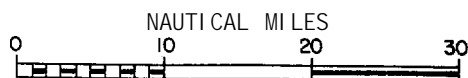


FIGURE 1

SHALLOW WATER STUDY SITES

IN

NORTHEASTERN GULF OF ALASKA



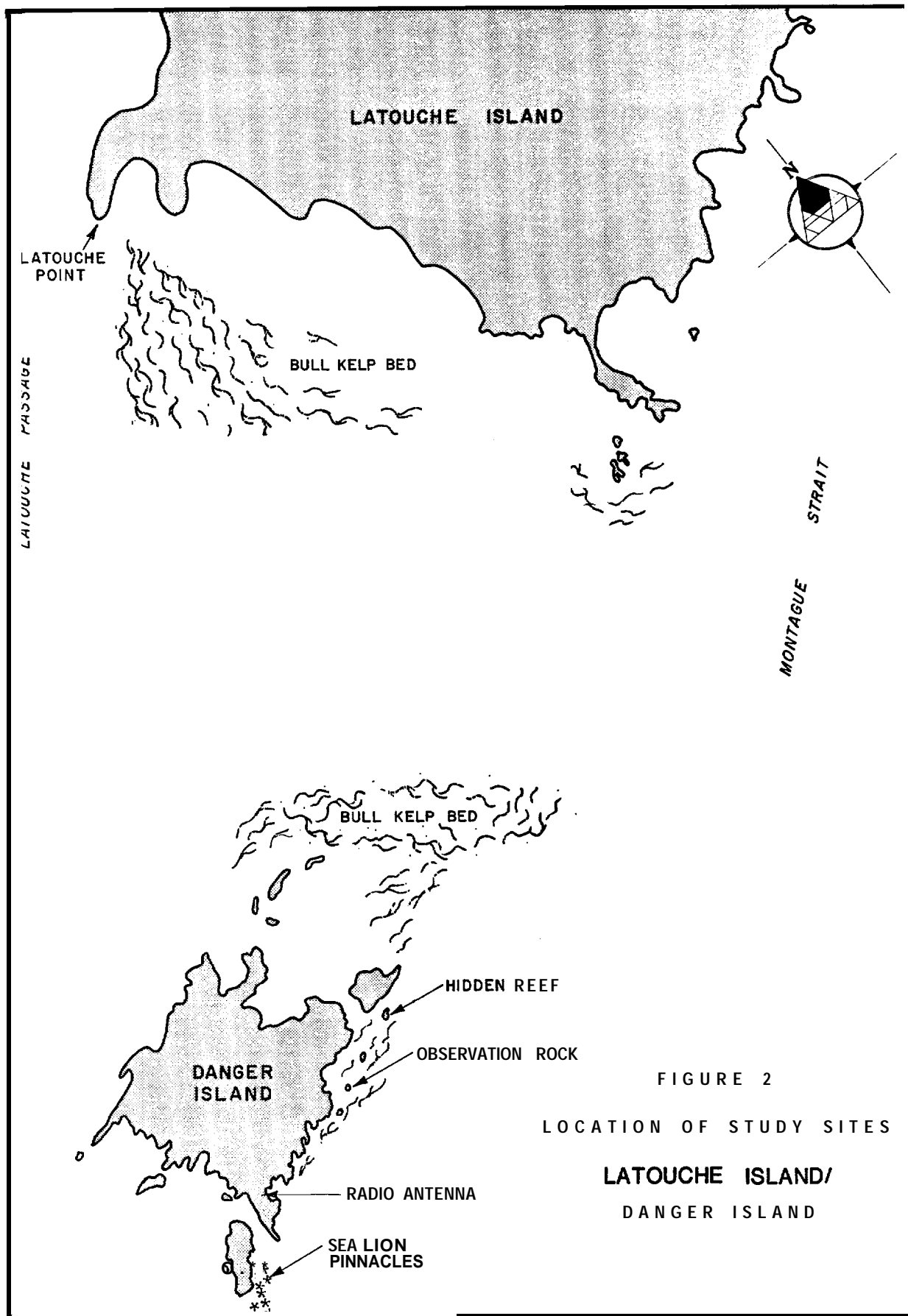
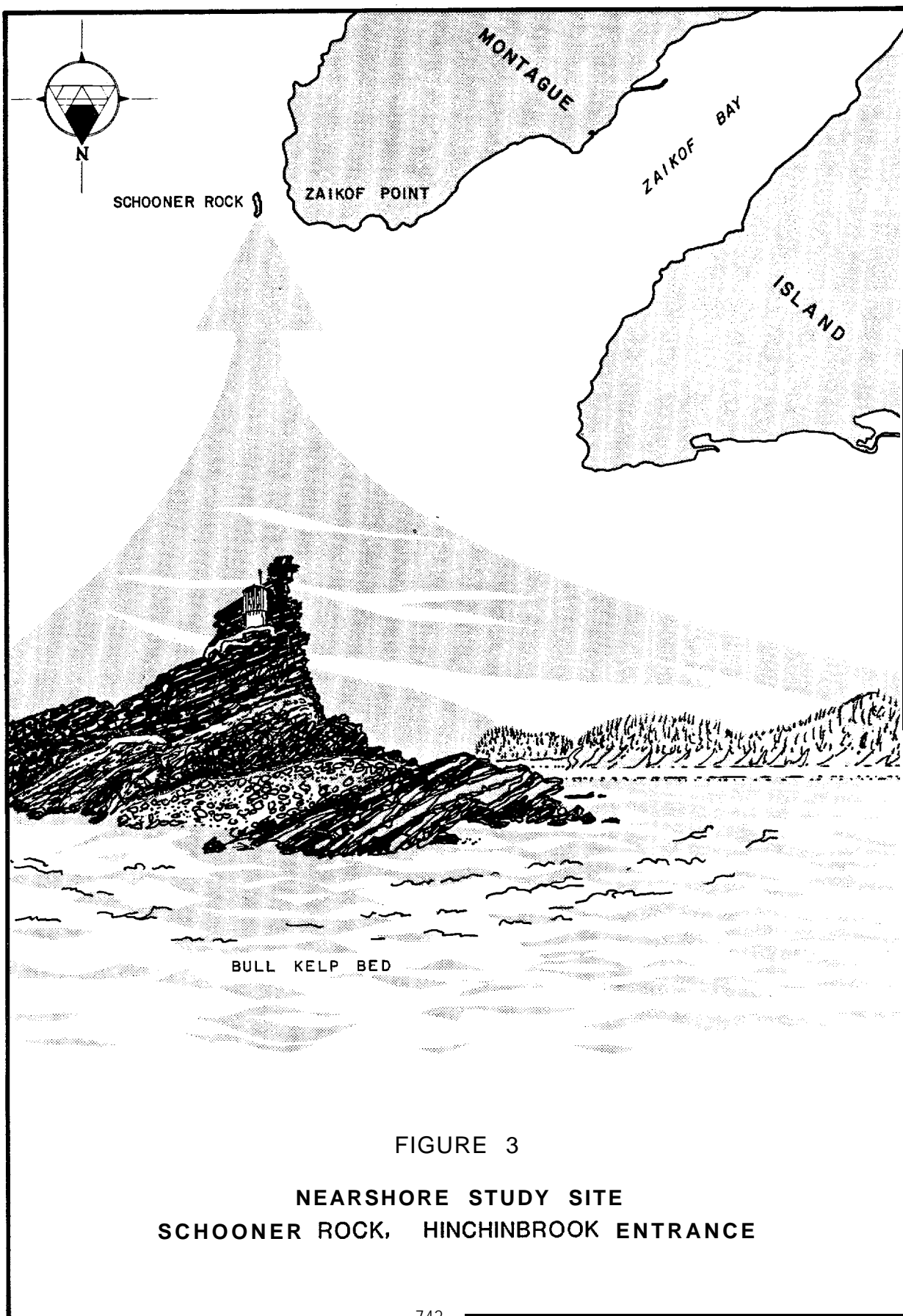


FIGURE 2
LOCATION OF STUDY SITES
LATOUCHE ISLAND/
DANGER ISLAND

The shallow subtidal zone is heterogeneous in relief. The bottom substratum consists primarily of rock pavement overlain by boulders and cobbles. Numerous fractures and surge channels cut through the rock substrate, usually the resulting depressions are collection points for coarse sands, gravel and shell debris. Vertical relief on the southern end of Danger Island is sharp, with recorded depths of 30 fathoms only a few hundred meters off the rocky shoreline. Most of the direct observations were made at "Hidden Reef", "Observation Rock", "Sea Lion Pinnacles" and "Latouche Point" (Figure 2). During summer months a large bed-of bull kelp (Nereocystis luetkeana) grew on the shoal area between Latouche Point and Danger Island, and smaller patches fringed the steeply sloped shores of Danger Island.

Schooner Island/Zaikof Point

A small rocky islet off the eastern end of Zaikof Point was chosen as the primary sampling station in Hinchinbrook Entrance. Most of the underwater observations were made on the north side of the island, below a light that has been installed as an aid to coastal navigation (Figure 3). The leeward (north) side of Schooner Rock appears to be somewhat protected from wave shock, however tidal currents are intense. For example, on an incoming tide the surface water boiled and eddied around the island with such force that underwater activities were generally confined to the north face of the reef. Conversely on an ebb, the opposite was in affect as the water flowed out of the Sound. The pulse was such that flotsam or debris drifting by on the sea surface usually reappeared on the next phase of the tide. The surface waters around the



reef are occasionally exposed to storm force winds that generally blow southeasterly from Port Etches in the direction of Zaikof Point.

Small stands of bull kelp grew close to Schooner Rock, and a much larger bed extended seaward off Zaikof Point. The underlying reef below the rocky intertidal zone was composed of pavements, cobbles and boulders. Vertical relief is gradual and then drops off sharply approximately 40 m from the shoreline. A submarine boulder field occurs at this point, around 12.0 meters below the sea surface. North of the boulder field is an expanse of sand interspersed with small rocks and shell debris. Above the boulder field the macrophytic cover was moderate to heavy, however below and out to a depth of 24 meters the benthic vegetation was sparse to absent.

Some physical oceanographic measurements were obtained during this time frame. Sea surface temperatures varied from 13.5 C to 14.0 C during the August (1977) survey. Water transparency was determined by making either visual observations while submerged, or estimating transparency with the aid of a standard white secchi disc. Estimates of downward irradiance averaged 8.0 meters, while corresponding horizontal visibility underwater ranged from 5.0 to 13.0 meters depending on the depth and the stage of the tide.

RESULTS

NEARSHORE FISHES AND THEIR HABITATS

Macrophyte Assemblage (exposed)

The marine macrophytes (seaweeds and seagrasses) formed a conspicuous band along the shores of Danger Island and Schooner Rock. The width of the band varied, however, it usually extended from the intertidal zone down to approximately 30 meters below the sea surface. Bull kelp (Nereocystis luetkeana) was the visual dominant in the floating canopy. Individual plants were found from the intertidal - subtidal fringe, out to depths of around 20 m. The average density of bull kelp during all sample periods was 0.35 ind./m² at Latouche Point and 1.48/m² at Danger Island (Rosenthal, 1977). Relative abundance was similar in Hinchinbrook Entrance; the average plant density in the bull kelp bed at Schooner Rock was 1.75 ind./m².

Beneath the floating or surface canopy was a multi-layered undergrowth of brown and red algae. These summer canopies were composed of the annual brown alga Cymathere triplicata, which covered substantial portions of the underlying sea floor. Another layer was comprised of Laminaria groenlandica, L. yezoensis, L. dentigera, and Pleurophycus gardneri. Pleurophycus was the most abundant kelp in the algal understory at Danger Island. The final layer of brown algae was dominated by sieve kelp (Agarum cribrosum) and hair-like growth forms of Desmarestia.

Below the brown algal guild were foliose reds such as

Callophyllis s p p., Ptilota filicina, Opuntiella californica, and Membranoptera spp.. Crustose and articulated corallines formed the final vegetative veneer on the rock surfaces. It is an extremely robust system; at least 60 species of macroalgae are commonly seen in shallow waters of the northern Gulf, and estimates of seaweed standing crop range as high as 20 kg fresh weight/m² during summer.

The seaweed canopies at both Danger Island and Schooner Rock provided food and cover for the animal components of the system. Of the some 44 species of fish collected from the area (Table 1), only about 9 species are listed as characteristic of outer coast or exposed macrophyte assemblages (Table 2). Both demersal and schooling pelagic fishes congregated in these nearshore habitats. For example, during August and early September, juvenile pacific herring (Clupea harengus pallasii) frequently appeared around the seaweed canopies. Juvenile herring also hovered in quite schools along the rocky shoreline, and feeding during daylight hours was directed at plankton drifting in the water column. Adult herring were not seen in these same habitats during summer months, however they did occur in the shallow sublittoral zone during spring.

Another important pelagic species, which occurred in dense schools at both study sites was the pacific sand lance (Ammodytes hexapterus). Sand lance also concentrated around the margins of the bull kelp forest, and these inshore schools frequently formed compact units which directed their feeding near the sea surface.

A third schooling species which occurred in this habitat was the

Table 1

**LIST OF FISHES CAPTURED IN THE NEARSHORE
WATERS OF THE NORTHEASTERN GULF OF ALASKA**

<u>COMMON NAME</u>	<u>SCIENTIFIC NAME</u>	<u>LOCATION</u>
Pink Salmon	<u>Oncorhynchus gorbuscha</u>	D,S
walleye Pollock	<u>Theragra chalcogramma</u>	s
Pacific Tomcod	<u>Microgadus proximus</u>	D,S
Pacific Cod	<u>Gadus macrocephalus</u>	S
Tube-Snout	<u>Aulorhynchus flavidus*</u>	D,S
Searcher	<u>Bathymaster signatus</u>	Port Valdez
Alaskan Ronquil	<u>B. caeruleofasciatus</u>	D,S
Pacific Sand Lance	<u>Ammodytes hexapterus</u>	D,S
Copper Rockfish	<u>Sebastes caurinus</u>	D
?Dusky Rockfish	<u>S. ciliatus</u>	D
Yellowtail Rockfish	<u>S. flavidus*</u>	D,S
Quillback Rockfish	<u>S. maliger</u>	D,S
Black Rockfish	<u>S. melanops</u>	D,S
China Rockfish	<u>S. nebulosus*</u>	D,S
Tiger Rockfish	<u>S. nigrocinctus</u>	s
Yelloweye Rockfish	<u>S. ruberrimus</u>	D
Kelp Greenling	<u>Hexagrammos decagrammus</u>	D,S
Rock Greenling	<u>H. lagocephalus</u>	D,S
Whitespotted Greenling	<u>H. stelleri</u>	D,S
Lingcod	<u>Ophiodon elongatus*</u>	D,S
Padded Sculpin	<u>Artedius fenestralis</u>	D,S
Sharpnose Sculpin	<u>Clinocottus acuticeps</u>	D
Antlered Sculpin	<u>Enophrys diceraus</u>	D
Red Irish Lord	<u>Hemilepidotus hemilepidotus</u>	D,S
Yellow Irish Lord	<u>H. jordani</u>	D
?Blackfin Sculpin	<u>Malacocottus kincaidi</u>	D
Great Sculpin	<u>Myoxocephalus polyacanthocephalus</u>	D
-----	<u>Myoxocephalus sp.</u>	D
Sailfin Sculpin	<u>Nautichthys oculofasciatus*</u>	Port Chalmers
Grunt Sculpin	<u>Rhamphocottus richardsoni</u>	D
Crested Sculpin	<u>Blepsias bilobus</u>	D,S
Silverspotted Sculpin	<u>B. cirrhosus</u>	D
Sturgeon Poacher	<u>Agonus acipenserinus</u>	S
Pacific Spiny Lumpsucker	<u>Eumicrotremus orbis</u>	S
Marbled Snailfish	<u>Liparis dennyi</u>	Port Fidelgo
Wolf-Eel	<u>Anarrhichthys ocellatus</u>	D,S
Snake Prickleback	<u>Lumpenus sagitta</u>	S
Arctic Shanny	<u>Stichaeus punctatus*</u>	D,S
Decorated Warbonnet	<u>Chirolophis decoratus</u>	Port Valdez
Crescent Gunnel	<u>Pholis laeta</u>	D
Pacific Herring	<u>Clupea harengus pallasi</u>	D,S
Pacific Halibut	<u>Hippoglossus stenolepis</u>	D,S
Rock Sole	<u>Lepidopsetta bilineata</u>	D,S
Yellowfin Sole	<u>Limanda aspera</u>	S
Starry Flounder	<u>Platichthys stellatus</u>	S

D = Danger Island/Latouche Point

S = Schooner Rock/Zaikof Bay

* = Range Extension

Table 2

CHARACTERISTIC FISHES MOST FREQUENTLY SEEN IN THE FOUR HABITATS DURING SUMMER

<u>Boulder Field</u>	<u>Macrophyte Assemblage (exposed)</u>	<u>Macrophyte Assemblage (protected)</u>	<u>Soft Bottom</u>
Kelp Greenling	Kelp Greenling	Kelp Greenling	Pacific Halibut
Lingcod	Rock Greenling	White-spotted Greenling	Rock Sole
Quillback Rockfish	Pacific Sandlance	Pacific Tomcod	Starry Flounder
China Rockfish	Black Rockfish	Tube-snout	Yellowfin Sole
Yellowtail Rockfish	Rockfish (juveniles)	Pacific Sandlance	Pacific Sandlance
Black Rockfish	Red Irish Lord	Copper Rockfish	
Tiger Rockfish	Pacific Herring (juvenile)	Rockfish (juveniles)	
Yelloweye Rockfish	Pacific Tomcod	Yellow Irish Lord	
Rockfish (juveniles)	Tube-snout	Pacific Herring	
Wolf-eel		Searcher	
Alaskan Ronquil		Arctic Shanny	
Red Irish Lord		Great Sculpin	
		Antlered Sculpin	
		Sturgeon Poacher	
		Rock Sole	
		Starry Flounder	
		Crescent Gunnel	
		Pink Salmon	
		Scalyhead Sculpin	
		Pacific Staghorn Sculpin	

tube-snout (Aulorhynchus flavidus). The reported northern range of Aulorhynchus was southeast Alaska (Quast and Hall, 1972), however, our observations extend the northern distribution of this species into Prince William Sound. Tube-snout usually concentrated in small schools around beds of seaweeds and seagrasses. Most of their foraging activities seemed to be directed at plankters that occurred on or near the bottom vegetation.

Aggregations of juvenile rockfish (Sebastes) appeared inshore during summer months. Sometimes these schools were mixed with different species, e.g. black rockfish (Sebastes melanops), yellowtail rockfish (S. flavidus) and numerous unidentified Sebastes. These rockfish were active during the day, and frequently hovered in small to moderate sized schools along the edges of the kelp forest. Most of the feeding was directed at prey species in the water column. Adult black rockfish also migrated into these shallower zones, however the adults were usually segregated from the juveniles.

The pacific tomcod (Microgadus proximus) was also found in these exposed locations. However, most of the individuals appeared to be large juveniles. Since their frequency and abundance was greater in more protected macrophyte assemblages, their biology will be presented in a following section.

Numerous solitary bottom dwellers were also common in these exposed habitats. One of these, the red Irish lord (Hemilepidotus hemilepidotus) was usually seen on a rocky bottom concealed by the

vegetative undergrowth. Estimates of density ranged from 0 to 0.04/m² at Schooner Rock (Tables 3 & 4), however, no H. hemilepidotus occurred in the band transects at Danger Island even though this species was seen on most of the dives. Four specimens were captured in these locations during August, 1977. The diet consisted heavily of a small rock crab, Cancer oregonensis; it occurred in 2/4 of the samples and made up 75 percent of the total prey. The other important prey species were a brittle star (Ophiopholis aculeata), hermit crabs (Pagurus spp.) and an unidentified cottid.

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Table 3
DENSITY ESTIMATES OF SOME CONSPICUOUS FISHES
AT SCHOONER ROCK, HINCHINBROOK ENTRANCE

<u>Species</u>	<u>8/15/77</u>	<u>8/16/77</u>	<u>8/16/77</u>	<u>8/16/77*</u>
<u>Sebastes melanops</u> (Black Rockfish)	0	0	0	0.28 0.05/m ²
<u>Sebastes nebulosus</u> (China Rockfish)	0	0	0	0
<u>Sebastes nigrocinctus</u> (Tiger Rockfish)	0	0	0	0
<u>Sebastes spp.</u> (Juveniles)	0	0	0	0
<u>Sebastes maliger</u> (Quillback Rockfish)	0	0	0	0
<u>Hexagrammos decagrammus</u> (Kelp Greenling)	2 0.08/m ²	3 0.05/m ²	4 0.07/m ²	2 0.03/m ²
<u>Hexagrammos lagocephalus</u> (Rock Greenling)	1 0.04/m ²	0	0	0
<u>Ophiodon elongatus</u> (Lingcod)	0	1 0.02/m ²	1 0.02/m ²	0
<u>Bathymaster caeruleofasciatus</u> (Alaskan Ronquil)	6 0.24/m ²	0	2 0.03/m ²	4 0.07/m ²
<u>Hemilepidotus hemilepidotus</u> (Red Irish Lord)	0	0	0	0
<u>Anarrhichthys ocellatus</u> (Wolf-Eel)	0	0	0	0
Area Sampled:	25 x 1m	30 x 2m	30 x 2m	30 x 2m
Depth (meters):	7.6-9.0	17.0-18.0	16.5	16.5
Substrate:	Bo & Ledg	Bo & Sa	Bo & Sa	Bo & Sa

* = Repeat of preceding transect (1-2 hrs. later in the day)

Table 4

DENSITY ESTIMATES OF SOME CONSPICUOUS FISHES
AT SCHOONER ROCK, HINCHINBROOK ENTRANCE

<u>Species</u>	<u>8/16/77</u>	<u>8/17/77</u>	<u>8/17/77</u>	<u>8/18/77</u>
<u>Sebastes melanops</u> (Black Rockfish)	0	11 0.12/m ²	31 0.52/m ²	0
<u>Sebastes nebulosus</u> (China Rockfish)	0	1 0.01/m ²	1 0.02/m ²	0
<u>Sebastes ninigröcinctus</u> (Tiger Rockfish)	0	1 0.01/m ²	0	0
<u>Sebastes spp.</u> (Juveniles)	10 0.33/m ²	0	0	0
<u>Sebastes maliger</u> (Quillback Rockfish)	0	1 0.01/m ²	2 (1.03/m ²)	0
<u>Hexagrammos decagrammus</u> (Kelp Greenling)	3 0.10/m ²	4 0.04/m ²	0	0
<u>Hexagrammos lagocephalus</u> (Rock Greenling)	0	0	0	0
<u>Ophiodon elongatus</u> (Lingcod)	0	1 0.01/m ²	0	0
<u>Bathymaster caeruleofasciatus</u> (Alaskan Ronquil)	0	24 0.27/m ²	0	0
<u>Hemilepidotus hemilepidotus</u> (Red Irish Lord)	0	1 0.01/m ²	0	1 0.04/m ²
<u>Anarrhichthys ocellatus</u> (Wolf-Eel)	0	0	0	2 0.08/m ²
Area Sampled:	15 x 2m	30 x 3m	30 x 2m	25 x 1m
Depth (meters):	11.5	13.5	12.5 - 13.5	16.5 - 18.0
Substrate:	Bo	Bo	Bo	Bo & Kelp

*. Report of Preceding transect (1-2 hrs. later in the day)

Hexagrammos decagrammus (Pallas) - Kelp Greenling

The kelp greenling was the most widely distributed and most numerous hexagrammid in the northern Gulf of Alaska. It was particularly common in exposed or semi-exposed habitats, which were dominated by rocky substratum and macroscopic algae. Kelp greenling were found as far north as Port Valdez, and the reputed southern range is La Jolla, California (Miller and Lea 1972). Density estimates at Danger Island during late August 1977 varied from 0 to $0.10/M^2$ with an average density in all of the band transects (1,008 sq. m) of $0.06/M^2$ (Tables 5-8). Estimates at Schooner Rock were remarkable similar; the range was 0 to $0.10/M^2$ and the average was $0.05/M^2$ in the 410 sq. m of sea floor that was examined during August 1977 (Tables 3 & 4).

The kelp greenling was commonly seen throughout the subtidal vegetative band; it was also one of the more conspicuous reef fishes in the boulder field habitat below -22 m (Figure 4). The color was highly variable depending on the time of year, reproductive state and habitat where each fish was collected. Generally there were two distinct color phases in mature H. decagrammus, the males were green to coppery brown with blue spots, and the females were brown to reddish orange with orange spots.

Twenty-seven specimens were collected for information on food habits and of these all 27 had some identifiable food items in their stomachs. Stomach fullness ranged from 10-100 percent, with an average fullness of 61.0 percent. These specimens ranged in size from 8.8 cm

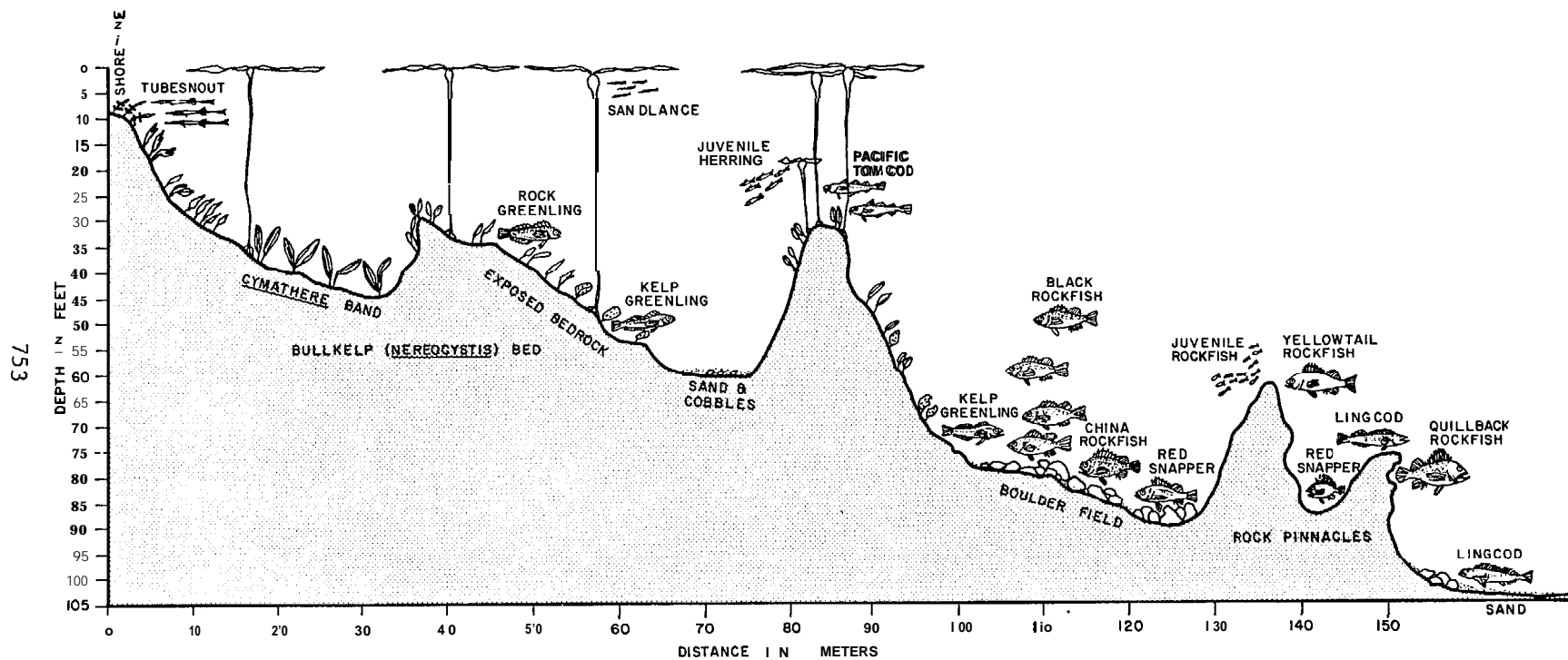


FIGURE 4

DISTRIBUTION OF FISHES IN RELATION TO HABITAT TYPE & DEPTH

DANGER ISLAND, MONTAGUE STRAIT
(SUMMER)

Table 5

DENSITY ESTIMATES OF SOME DOMINANT
FISHES FROM THE S.W. END OF DANGER ISLAND

<u>Species</u>	<u>8/26/77</u>	<u>8/26/77</u>	<u>8/27/77</u>	<u>8/27/77</u>	<u>8/27/77</u>	<u>8/27/77*</u>
<u>Sebastes melanops</u> (Black Rockfish)	2 0.04/m ²	10 0.22/m ²	0	8 0.20/m ²	0	0
<u>Sebastes nebulosus</u> (China Rockfish)	1 0.02/m ²	0	0	0	0	0
<u>Sebastes ruberrimus</u> (Red Snapper)	1 0.02/m ²	0	0	0	0	0
<u>Sebastes flavidus</u> (Yellowtail Rockfish)	0	0	0	5 0.13/m ²	0	0
<u>Sebastes maliger</u> (Quillback Rockfish)	0	0	0	0	0	0
<u>Hexagrammos decagrammus</u> (Kelp Greenling)	2 0.04/m ²	3 0.07/m ²	3 0.08/m ²	3 0.08/m ²	4 0.05/m ²	6 0.08/m ²
<u>Hexagrammos lagocephalus</u> (Rock Greenling)	0	0	1 0.03/m ²	0	0	0
<u>Ophiodon elongatus</u> (Lingcod)	0	0	0	0	0	0
<u>Bathymaster caeruleofasciatus</u> (Alaskan Ronquil)	0	1 0.02/m ²	0	0	0	0
Area Sampled:	30 x 1.5m	30 x 1.5m	20 x 2m	20 x 2m	26 x 3m	25 x 3m
Depth (meters)	23.0	23.0	19.5	24.0	13.5 -16.5	13.5 -16.5
Substrate:	Bo & Rk	Bo & Rk	Rk	Bo & Rk	Bo & Rk	Bo & Rk

* = Repeat of preceding transect (1-2 hrs. later in the day)

Table 6

DENSITY ESTIMATES OF SOME CONSPICUOUS
FISHES FROM THE S.W. END OF DANGER ISLAND

<u>Species</u>	<u>8/28/77</u>	<u>8/28/77</u>	<u>8/28/77</u>	<u>8/29/77</u>	<u>8/29/77*</u>
<u>Sebastes melanops</u> (Black Rockfish)	8 0. 16/m ²	2 0. 04/m ²	0	0	0
<u>Sebastes nebulosus</u> (China Rockfish)	1 0.02/m ²	0	0	0	0
<u>Sebastes ruberrimus</u> (Red Snapper)	0	1 0. 04/m ²	0	0	0
<u>Sebastes flavidus</u> (Yellowtail Rockfish)	0	0	0	0	0
<u>Sebastes maliger</u> (Quillback Rockfish)	1 0.02/m ²	0	0	0	0
<u>Hexagrammos decagrammus</u> (Kelp Greenling)	3 0. 06/m ²	0	4 0. 07/m ²	2 0.04/m ²	5 0. 1 0/m ²
<u>Hexagrammos lagocephalus</u> (Rock greenling)	0	0	0	0	0
<u>Ophiodon elongatus</u> (Lingcod)	2 0. 04/m ²	2 0. 04/m ²	0	0	0
<u>Bathymaster caeruleofasciatus</u> (Alaskan Ronquil)	1 0.02/m ²	0	0	1 0.02/m ²	0
Area Sampled:	25 x 2m	25 x 2m	30 x 2m	25 x 2m	25 x 2m
Depth (meters):	24.0-26.0	30.0	20.0-24.0	18.0	18.0
Substrate:	Rk	Rk & Sa	Bo & Sa	Rk & Bo	Rk & Bo

* = Repeat of Preceding Transect (1-2 hrs. later in the day)

Table 7

DENSITY ESTIMATES OF SOME CONSPICUOUS
FISHES FROM THE S.W. END OF DANGER ISLAND

<u>Species</u>	<u>8/29/77</u>	<u>8/29/77*</u>	<u>8/29/77</u>	<u>8/29/77*</u>	<u>8/29/77</u>	<u>8/29/77</u>
<u>Sebastes melanops</u> (Black Rockfish)	0	0	0	0	1 0.02/m ²	5 0.08/m ²
<u>Sebastes nebulosus</u> (China Rockfish)	0	0	0	0	0	0
<u>Sebastes ruberrimus</u> (Red Snapper)	0	0	0	0	0	0
<u>Sebastes flavidus</u> (Yellowtail Rockfish)	0	0	0	0	0	0
<u>Sebastes maliger</u> (Quillback Rockfish)	0	0	0	0	0	0
<u>Hexagrammos decagrammus</u> (Kelp Greenling)	2 0.04/m ²	2 0.04/m ²	3 0.06/m ²	5 0.10/m ²	4 0.07/m ²	4 0.07/m ²
<u>Hexagrammos lagocephalus</u> (Rock greenling)	0	0	1 0.02/m ²	0	0	0
<u>Ophiodon elongatus</u> (Lingcod)	0	0	0	0	0	0
<u>Bathymaster caeruleofasciatus</u> (Alaskan Ronquil)	0	0	0	0	0	0
Area Sampled:	25 x 2m	25 x 2m	25 x 2m	25 x 2m	30 x 2m	30 x 2m
Depth (meters)	14.5-8.0	4.5-8.0	14.0-17.5	14.0-7.5	3.5-15.0	13.5-15.0
Substrate:	Rk & Bo	Rk & Bo	Rk & Bo	Rk & Bo	Rk & Bo	Rk & Bo

* = Repeat of preceding transect (1-2 hrs. later in the day)

Table 8

DENSITY ESTIMATES OF SOME CONSPICUOUS
FISHES FROM THE S. I d. ~~END OF DANGER ISLAND~~

<u>Species</u>	8/30/77	8/30/77*
<u>Sebastes melanops</u> (Black Rockfish)	17 0.31/m ²	11 0.20/m ²
<u>Sebastes nebulosus</u> (China Rockfish)	1 0.02/m ²	2 0.04/m ²
<u>Sebastes ruberrimus</u> (Red Snapper)	1 0.02/m ²	0
<u>Sebastes flavidus</u> (Yellowtail Rockfish)	0	0
<u>Sebastes maliger</u> (Quillback Rockfish)	0	0
<u>Hexagrammos decagrammus</u> 7 Kelp Greenling	1 0.02/m ²	1 0.02/m ²
<u>Hexagrammos lagocephalus</u> (Rock Greenling)	0	0
<u>Ophiodon elongatus</u> (Lingcod)	1 0.02/m ²	1 0.02/m ²
<u>Bathymaster caeruleofasciatus</u> (Alaskan Ronquil)	0	1 0.02/m ²
Area Sampled:	27 x 2m	27 x 2m
Depth (meters):	22.5 - 24.0	22.5 - 24.0
Substrate:	Bo	Bo

* = Repeat of preceding transect (1-2 hrs. later in the day)

(10.0 g) to 42.0 cm (1 , 350 g) and the average H. decagrammus was 29.6 cm. At least 36 different categories of food items are listed in Table 9, and the major ones are crustaceans, mollusks and fish eggs. Gammaridean amphipods were the major prey species of the kelp greenling in these study areas, and this represented 60.0 percent (N=312) of the total identifiable food items. The kelp greenling is a highly opportunistic predator in the inshore zone and it dined on a variety of prey ranging from zooplankters to the eggs of conspecifics. This foraging versatility is expressed by the diet of one individual (31.5 cm) that was collected off the southwest end of Danger Island. The specimen was a female, and it was found to have eaten a cluster of greenling eggs, 1 sand lance (Ammodytes hexapterus), 2 decorator crabs (Pugettia gracilis), 1 rock crab (Cancer oregonensis), 2 gastropod (Velutina sp.), 8 gammarid amphipods and pieces of red and brown algae.

Table 9

FOOD OF KELP GREENLING (Hexagrammos decagrammus)
FROM THE NORTHEASTERN GULF OF ALASKA (N=27)

<u>Food Items</u>	<u>Frequency of Occurrence</u>	<u>Number</u>	<u>Percentage of Total</u>
Gammaridean amphipods	19/36	312	60.0
Caprellid amphipods	5/36	28	5.3
Caridean shrimps	4/36	4	0.7
Brachyuran juveniles	6/36	20	3.8
Tanaids	1/36	1	0.1
<u>Pugettia gracilis</u>	13/36	23	4.4
(crab)			
<u>Cancer oregonensis</u>	8/36	12	2.3
(crab)			
<u>Idothea</u> sp.	1/36	1	0.1
(isopod)			
<u>Margarites helycinus</u>	1/36	2	0.3
(snail)			
<u>Synoicum</u> sp.	6/36	6	1.1
(ascidian)			
<u>Telmessus cheiragonus</u>	1/36	1	0.1
(crab)			
<u>Pagurus</u> sp.	1/36	1	0.1
(hermit crab)			
<u>Velutina</u> spp.	8/36	15	2.4
(snail)			
<u>Lacuna</u> variegata	1/36	3	0.5
(snail)			
Opisthobranchs	1/36	2	0.3
Polychaetes	7/36	22	4.2
Rhodophyta	6/36	6	1.1
(red algae)			
Fish eggs	4/36	4	0.7
<u>Musculus</u> spp.	8/36	15	2.8
(mussel)			
<u>Eupentacta</u> sp.	2/36	5	0.9
(sea cucumber)			
<u>Elassochirus gilli</u>	1/36	1	0.1
(hermit crab)			
<u>Microporina borealis</u>	1/36	1	0.1
(bryozoan)			
<u>Ophiopholis aculeata</u>	1/36	1	0.1
(brittle star)			
Mysids	3/36	8	1.5
<u>Hiatella arctica</u>	1/36	1	0.1
(bivalve)			
<u>Euphrosine</u> sp.	2/36	2	0.3
(polychaete)			

Table 9 (cont.)

<u>Food Items</u>	<u>Frequency of Occurrence</u>	<u>Number</u>	<u>Percentage of Total</u>
<u>Ammodytes hexapterus</u> (fish)	1/36	1	0.1
<u>Didemnum sp.</u> (ascidian)	2/36	2	0.3
<u>Polyplacophora</u> (chiton)	1/36	1	0.1
<u>Phaeophyta</u> (brown algae)	2/36	2	0.3
<u>Fusitriton operculum</u> (snail)	1/36	8	1.5
<u>Munnidae</u> (isopod)	1/36	1	0.1
<u>Abietinaria sp.</u> (hydroid)	2/36	2	0.3
<u>Gastropoda</u> (snails)	2/36	2	0.3
<u>Crucigera operculum</u> (serpulid)	1/36	1	0.1
<u>Fishes</u>	4/36	4	0.7

Hexagrammos lagocephalus (Pallas) - Rock Greenling

The rock greenling, Hexagrammos superciliosus was synonymized with H. lagocephalus by Quast (1964). Rock greenling, which can exceed a total length of 38.0 cm, was especially numerous in the shallow portions of the subtidal zone. Frequently it was seen resting on a bottom dominated by macroalgae, at other times it was observed swimming slowly through the vegetative undergrowth. Most were solitary in distribution; estimates of density ranged from 0 to 0.04/M² at Schooner Rock (Tables 3 & 4), to 0 to 0.03/M² off the southwest end of Danger Island (Tables 5-8). During summer months most individuals were observed in the shallow to mid-depth region of the bull kelp beds off Danger Island and Schooner Rock (Figures 4 & 5).

The activity pattern of the rock greenling seemed to change markedly during the year. For example, during the period from late fall to early spring most of the H. lagocephalus were cryptic or secretive in habit and hid under formations of rock and seaweed. However, with the onset of the reproductive and spawning season (June - September), the rock greenling assumed a more overt, highly visible posture. Most of these "aggressive" individuals were brightly colored males. Mature males ranged from a reddish-brown to a blood-red body coloration, mottled with green and turquoise blue. The inside of the mouth is frequently blue. Nest guarding males were observed from July through mid-September. The eggs were usually deposited in small clusters attached to kelp holdfasts, articulated corallines and even hair-like branches of Desmarestia aculeata. Male rock greenling defend the nests against all

intruders - attacking not only conspecifics but also other bottom fishes, crabs and even divers. Mouth fighting by male *H. laoccephalus* has been observed on three different occasions. The females were more subdued in coloration, most were greenish-brown, mottled with yellow and red. The female rock greenling has not been seen in association with a nest that is being guarded by a vigilant male.

All the 16 individuals collected in these areas during daylight hours had food items present in their stomachs. These specimens ranged in size from 14.0 to 38.0 cm, and averaged 25.4 cm. Stomach fullness ranged from 20-90 percent, with the average at 51 percent. The condition of the prey and the degree of stomach fullness suggests that the rock greenling feeds heavily during daylight hours. A total of 28 different categories of food were taken by these rock greenling (Table 10). The numerical dominant was gammaridean amphipods which accounted for 77.1 percent (N=301) of the total food items. Snails, crabs, mussels and fish eggs were also important constituents of the rock greenling diet in this geographical location. These data agree with the findings of Simenstad and Nakatani (1977) who found that gammarids dominated the prey composition of the rock greenling at Attu Island, Alaska. Rock greenling are omnivorous and as such ingest small quantities of algae incidental to the uptake of animal material. Fish eggs were common in the stomachs of male rock greenling, and one individual (29.0 cm) that was collected at Danger Island had a stomach that was 40 percent full of the eggs of a nonspecific. Nest-robbery seems to be a common practice in the hexagrammids.

Table 10

FOOD OF ROCK GREENLING (*Hexagrammos lagocephalus*)
FROM THE NORTHEASTERN GULF OF ALASKA (N=16)

<u>Food Items</u>	<u>Frequency of Occurrence</u>	<u>Number</u>	<u>Percentage of Total</u>
Gammaridean amphipods	11/16	301	77.1
Caprellid amphipods	1/16	1	0.2
Caridean shrimps	3/16	3	0.7
Brachyuran juveniles	1/16	1	0.2
Tanaids	3/16	4	1.0
Cummaceans	1/16	1	0.2
Polychaetes	4/16	5	1.2
<u>Musculus vernicosus</u> (mussel)	3/16	6	1.5
<u>Idothea sp.</u> (isopod)	2/16	2	0.5
<u>Gnorimosphaeroma oregonensis</u> (isopod)	2/16	3	0.7
<u>Psolus chitonoides</u> (sea cucumber)	1/16	1	0.2
<u>Margarites helycinus</u> (snail)	1/16	2	(-)0.5
Fish eggs	5/16	5	1.2
<u>Mitrella spp.</u> (snail)	2/16	2	0.5
<u>Velutina sp.</u> (snail)	2/16	7	1.7
<u>Oregonia gracilis</u> (crab)	1/16	1	0.2
<u>Trophon sp.</u> (snail)	1/16	1	0.2
<u>Synoicum sp.</u> (ascidian)	2/16	2	0.5
<u>Pagurus sp.</u> (hermit crab)	1/16	1	0.2
<u>Abietinaria sp.</u> (hydroid)	2/16	2	0.5
<u>Metridium senile</u> (sea anemone)	1/16	1	0.2
<u>Didemnum sp.</u> (ascidian)	1/16	1	0.2
Rhodophyta (red algae)	6/16	6	1.5
<u>Hyas lyrata</u> (crab)	1/16	3	0.7
<u>Ophiopholis aculeata</u> (brittle star)	1/16	1	0.2
<u>Cancer oregonensis</u> (crab)	1/16	1	0.2
<u>Pugettia gracilis</u> (crab)	4/16	5	1.2
Lacuna spp.	3/16	21	5.3

m

Subtidal Boulder Field (exposed)

The solid substratum below the macrophyte band covers a wide variety of geological **facies**, ranging from patches of gravel and cobbles to extensive reefs composed of rock pavement and boulders. Typically, the **biota** is attached to, or associated with the hard substrate. The boulder field habitat at Danger Island occurs as shallow as -22 m off the south end of the **island** (Figure 4), whereas the upper portion of the boulder field at Schooner Rock is less than 12 m below MLLW (Figure 5). Despite these obvious differences in bathymetry and distance from shore, the habitats are remarkably similar in appearance. From a distance the boulders have the general appearance of being bare, and yet upon closer inspection the rock surfaces display a wide assortment of **epibiota** ranging from crustose coral line algae to compound **ascidians** and **bryozoans**. Most of the macroscopic plant life was comprised of short statured or decumbent growth forms. This was usually the case with the **sessile macro-invertebrates**, except on some of the boulders there were large sea anemones such as Metridium senile, Cribrinopsis sp. and Tealia spp..

The submarine boulder fields supported high densities of bottom or **demersal** fishes during August, 1977. The number of species or **species richness** was also relatively high during summer, and this might be due in part to the physical stability of the habitat. The boulder formations provide a complexity of shelters and microhabitats, which are **apparently** needed to support such a high density of fish life. Usually the **demersal** fishes hovered close to the sea floor, or remained under the cover of the reef complex.

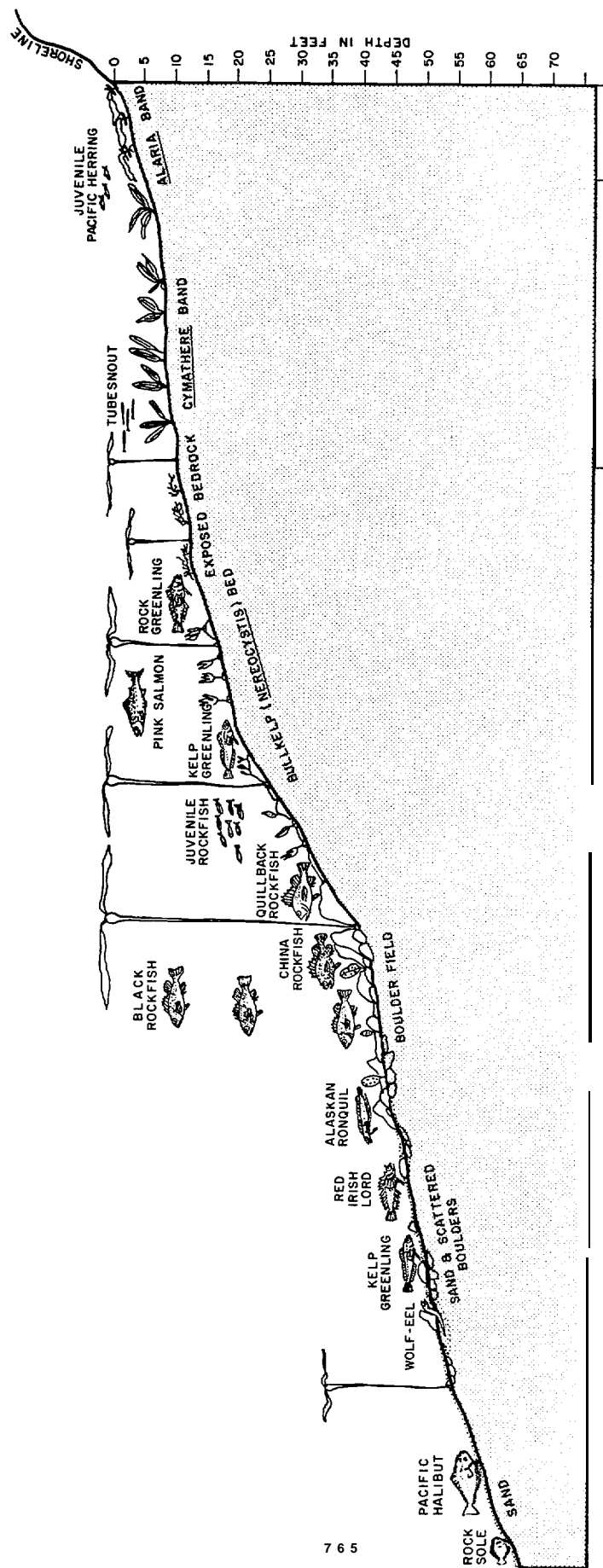


FIGURE 5

DISTRIBUTION OF FISHES IN RELATION TO HABITAT TYPE & DEPTH

SCHOONER ROCK, HINCHINBROOK ENTRANCE

(SUMMER)

The **rockfishes** were the most conspicuous group of bottom fishes in this assemblage. Six species were commonly seen during daylight hours. One of these, the **quillback rockfish (Sebastes maliger)**, had a maximum recorded density of $0.03/M^2$ at Schooner Rock (Table 4), and $0.02/M^2$ off the southern end of Danger Island (Table 6). Most of the larger quillbacks occurred below -25 m, and were *seen* either **resting** on rock walls or hovering around pinnacles and rock **piles**. Three of the **quillback rockfish** that were examined for food items had consumed **gammaridean amphipods, mysids, cummaceans** and **caridean shrimp**.

One species that was previously unreported in Prince William Sound was the **tiger rockfish (Sebastes nigrocinctus)**. The previous northern range of the **tiger rockfish** was southeastern Alaska (Hart, 1973), although recently Quast and Hall (1972) extended the range northward to Cape Resurrection on the outer **Kenai Peninsula**. A large, solitary **S. nigrocinctus** was observed and subsequently photographed in a small cave at -15.0 m off the north **end of** Schooner Rock. This was the only **tiger rockfish** that was seen during August, 1977, however its' abundance could be greater since most probably go unnoticed because of their retiring nature.

Small schools of **yellowtail rockfish (Sebastes flavidus)** occurred at Danger Island; estimates of density ranged from 0 to $0.13/M^2$ (Tables 5-8). Previous reports list the range of the **yellowtail rockfish** from San Diego, California to Kodiak Island (Miller and Lea, 1972). Juvenile **S. flavidus** frequently were seen along the margins of bull kelp

forests, whereas larger individuals occurred above the boulder fields. Pereyra, Percy and Carvey (1969) examined the stomach contents of yellow-tail rockfish collected off the coast of Washington, and found that 90 percent of the food items were mesopelagic organisms such as the northern lampfish (Stenobranchius leucopsarus), crustaceans and squid. Conversely, the bulk of this species diet in the nearshore waters of Washington State was amphipods (Miller, Simenstad and Moulton, 1976). As yet, no information is available on the food habits of S. flavidus from the northeastern Gulf of Alaska.

At these same depths we encountered the wolf-eel (Anarrhichthys ocellatus) hiding in the crevices of the reef. Most are secretive and usually remain under cover, except when feeding or protruding the head from a crevice or rock pile. Numerous small wolf-eels occurred in the boulder field at Schooner Rock; density estimates ranged from 0 to 0.08/m² (Tables 3 & 4). Because of their secretive nature abundance was difficult to assess. However, one clue to their presence is the food debris or middens which frequently collect at the base of their lairs. Pieces of sea urchins, broken clam shells and crab remains were seen in wolf-eel lairs at Danger Island. Also, a direct observation of a large wolf-eel (>182 cm) feeding on green sea urchins was made while diving in the entrance channel to Constantine Harbor, Hinchinbrook Island (Rosenthal, 1977).

Two other fishes that were frequently seen in this habitat were the kelp greenling (H. decagrammus) and the red irish lord (H. hemilepidotus). Available information on both species was reported in the preceding section on exposed macrophyte assemblages.

Bathymaster caeruleofasciatus Gilbert & Burke - Alaskan Ronquil

The Alaskan ronquil (**Bathymaster caeruleofasciatus**) is a common member of the inshore fish assemblages of the Gulf of Alaska. This elongate, slender fish was the most numerous member of the family Bathymasteridae. Captured specimens ranged in length from 11.7 to 24.3 cm, and had an average fresh weight of 116 grams. The color was variable, some were dark olive to bluish green, while others were mottled with saddle markings on the body. **Bathymaster caeruleofasciatus** characteristically inhabits rocky overhangs, crevices and boulder fields. It was rarely seen to move out of **this** habitat, except to pursue food items or give chase to **conspecifics** and/or other members of the benthic community. Territorial **behaviour** was pronounced. Aggressive defense of a territory or home crevice in the form of mouth fighting was observed at Schooner Rock on two different occasions.

Estimates of **B. caeruleofasciatus** density ranged from 0 to .27/M² at Schooner Rock (Tables 3 & 4). The average density was 0.08/M² in the 410 square meters of sea floor that was examined **quantitatively** during mid-August, 1977. Conversely, this same species was much less abundant at Danger Island where densities ranged from 0 to 0.02/M² and averaged less than 0.01/M² in the 7,008 square meters of sea bottom examined during late August, 1977 (Tables 5 & 8).

The diet was variable and consisted of **macroinvertebrates** and **zooplankters** that were often times associated with **benthic** vegetation (Table 11). Ten specimens were captured during this time period, and of

Table 11

FOOD OF ALASKAN RONQUIL (*Bathymaster caeruleofasciatus*)
FROM THE NORTHEASTERN FULF OF ALASKA (N=10)

<u>Food Items</u>	<u>Frequency of Occurrence</u>	<u>Number</u>	<u>Percentage of Total</u>
Gammaridean amphipods	5/10	25	43.1
Caprellid amphipods	2/10	9	15.5
Caridean shrimps	1/10	1	1.7
Brachyuran Juveniles	1/10	2	3.4
<u>Ophiopholis aculeata</u> (brittle star)	5/10	10	17.2
<u>Velutina</u> spp. (snail)	2/10	2	3.4
Tanaids	1/10	2	3.4
<u>Paralithodes kamtschatica</u> (juvenile king crab)	1/10	2	3.4
<u>Musculus vernicosus</u> (mussel)	1/10	1	1.7
Polychaetes	1/10	2	3.4
<u>Crepidula</u> sp. (snail)	1/10	1	1.7
Rhodophyta (red algae)	1/10	1	1.7

these, 9 had food items in their stomachs. Gammaridean amphipods comprised 43.1 percent of the total identifiable prey. Another important prey species was the brittle star (Ophiopholis aculeata) which occurred in 17.2 percent of the diets; frequency of occurrence was 5/10 and one specimen had 5 brittle stars in the gut. Other important prey were caprellid amphipods, juvenile brachyuran crabs, juvenile king crab (Paralithodes~~kamtschatica~~) unidentified polychaetes and a snail—Velutina spp.

Sebastes nebulosus Ayres - China Rockfish

China rockfish were observed in the shallow waters of Montague Strait and Hinchinbrook Entrance. These direct observations extend the northern range of this fish from southeastern Alaska (Quast and Hall, 1972) to the southern reaches of Prince William Sound. This geographical extension is not startling, but what is interesting is the china rockfish is such a common member of the nearshore zone, where previously it was unreported. Sebastes nebulosus inhabits subtidal rocky outcrops, pinnacles and boulder fields below about -15 meters. Usually solitary in distribution; the china rockfish was rarely seen more than 1-2 meters off the sea floor. Frequently associated with the yelloweye rockfish (S. ruberrimus) and the quillback rockfish (Sebastes maliger), which seem to occupy similar types of microhabitats.

Density estimates ranged from 0 to $0.04/M^2$ at Danger Island (Tables 5-8), to between 0 and $0.02/M^2$ for the population at Schooner Rock (Tables 3 & 4). The average density was remarkably similar at both sites, with estimates of less than $0.01/M^2$.

Six individuals ($\bar{x} = 29.9$ cm) were collected from these two sites during 1977. The stomachs of all six contained food items, and the major food was a brittle star (Ophiopholis aculeata); this one item accounted for 74.1 percent of the total prey (Table 12). One china rockfish (37.0 cm) that was collected off Danger Island had 39 fresh O. aculeata in its stomach while another specimen that was taken at Schooner Rock had 13 brittle stars in the gut. The second most important prey

Table 12

FOOD OF CHINA ROCKFISH (Sebastes nebulosus)
FROM THE NORTHEASTERN GULF OF ALASKA (N=6)

<u>Food Items</u>	<u>Frequency of Occurrence</u>	<u>Number</u>	<u>Percentage of Total</u>
<u>Ophiopholis aculeata</u> (brittle star)	6/6	63	74.1
<u>Cancer oregonensis</u> (crab)	3/6	5	5.8
<u>Pugettia gracilis</u> (crab)	5/6	11	12.9
<u>Pagurus sp.</u> (hermit crab)	1/6	1	1.7
<u>Cancer branneri</u> (crab)	1/6	1	1.1
<u>Heteropora sp.</u> (bryozoan)	1/6	1	1.7
<u>Sclerocrangon sp.</u> (shrimp)	1/6	1	1.1
<u>Microporina borealis</u> (bryozoan)	1/6	1	1.1
<u>Abietinaria sp.</u> (hydroid)	1/6	1	1.1

species was a decorator crab (Pugettia gracilis); frequency of occurrence was 5/6, and this species accounted for 12.9 percent of the total identifiable food items. Another crab that was important in the diet was Cancer oregonensis; it was third in importance and accounted for 5.8 percent of the total.

Sebastes melanops Girard - Black Rockfish

The black rockfish was the most commonly observed species of schooling fish in the shallow waters of the Gulf. The northern range of this species was extended to Port Valdez, however the largest concentrations of black rockfish were either seen along the exposed outer coast or in ocean entrances leading into the Gulf. Some of the schools contained hundreds of S. melanops, typically the juvenile or immature fish were segregated from the adults. Black rockfish were most often seen along the outer edges of bull kelp forests, near rock pinnacles or around submarine boulder fields.

Estimates of density ranged from 0 to $.52/M^2$ at Schooner Rock (Tables 3 & 4). Similar densities were obtained for the S. melanops population at Danger Island, where counts ranged from 0 to $.31/M^2$ (Tables 5-8). These estimates are extremely conservative, since only those fish that occurred near the bottom were included in the counts. Some of the largest schools extended from the bottom up through the water column to approximately 5 meters from the sea surface. In these instances abundance could not be estimated by the band transect or line intercept method. Schools of juvenile S. melanops frequently aggregated with other juvenile rockfish.

Eighteen specimens were collected from the two major study sites; these individuals ranged from 17.0 to 49.0 cm. Sebastes melanops was collected during daylight hours; the stomachs were empty in 5 specimens, and in 7 of the 18 the food items were unidentifiable. Those prey that were

identified were **planktonic** forms such as jellyfish, ctenophores, juvenile fishes, **gammaridean amphipods** and swimming **polychaetes** (Table 13). Unlike some of the other Sebastes which pluck their food items from the bottom, the black **rockfish** forage in the water column for **drifting** or pelagic forms.

Table 13

FOOD OF BLACK ROCKFISH (Sebastes melanops)
FROM THE NORTHEASTERN GULF OF ALASKA (N=13)

<u>Food Items</u>	<u>Frequency of Occurrence</u>	<u>Number</u>	<u>Percentage of Total</u>
? <u>Beroe</u> sp. (ctenophore)	1/13	3	13.0
Polychaetes, swimming	1/13	2	8.6
Fishes, unid.	3/13	3	13.0
Gammaridean amphipods	1/13	4	17.3
Hydromedusae	2/13	2	8.6
Other	9/13	9	39.1

Sebastes ruberrimus Cramer - Yelloweye Rockfish

The yelloweye rockfish or red snapper as it is commonly known occurs from Ensenada, Mexico (Miller and Lea, 1972) to the Gulf of Alaska (Hart, 1973). Recently, juvenile S. ruberrimus have been observed as far north as Seal Rocks, Port Valdez, and this observation probably represents the northern range of this species in the eastern Pacific. The extensive distribution and high marketability of the flesh has made S. ruberrimus a highly sought after commercial species. It has been rarely seen by divers above a depth of 25 meters. Solitary in distribution, frequently associated with rock crevices, overhanging ledges and caves. Superficially the habitat requirements of this species appears to be similar to the china rockfish (S. nebulosus), which was repeatedly seen in close proximity to the red snapper.

Yelloweye rockfish were first observed at Danger Island during August, 1977; the maximum recorded density at this time was 0.04/M² (Table 8). Sebastes ruberrimus was not encountered at Schooner Rock, however this was probably due to our oversight. rather than the species being absent from Hinchinbrook Entrance. Four S. ruberrimus were captured from the subtidal zone at Danger Island; these specimens ranged from 58.5 cm to 66.0 cm. Two of the fishes had identifiable prey in their stomachs, in the others the stomachs were empty. The prey in both cases was a brightly colored lithodid crab. Placetron wosnesenskii. One of the rockfish had 2 of these crabs in it's stomach. The stomach was 80 percent full. Little else is known about the diet, except Hart (1973) reported that Sebastes ruberrimus eats crustaceans-and lingcod spawn in the Pacific northwest.

Ophiodon elongatus Girard - Lingcod

Lingcod are known to range as far north as Port Fidalgo in north-eastern Prince William Sound. Generally, they appear to be more abundant along exposed parts of the coastline than in sheltered waters such as Prince William Sound. During summer months the fish were most frequently observed on solid substrata below about -22.0 m. Most of the O. elongatus were seen on a sea floor dominated by boulders, rocky outcrops and high relief pinnacles (Figure 4). Lingcod were rarely seen swimming more than a few meters off the bottom. Large fish were aggressive, and seemed to be territorial.

Known to be voracious feeders on fishes, including herring, sand lance, flounder, hake, walleye pollock, cod and rockfish (Hart, 1973). Only five individuals were collected during the course of this study, and in these, the food items-consisted of black rockfish (S. melanops); unidentified Sebastes and Octopus sp.. Direct observations have also been made of their foraging habits. For example, on one occasion our Presence frightened a black rockfish that was immediately pursued and captured by a large lingcod that was hiding in a concealed position.

Lingcod grow to a reported length of 152 cm, and weigh up to 47 kg off the coast of British Columbia (Hart, 1973). To date, however, no lingcod have been collected in either Hinchinbrook Entrance or Montague Strait which approach this reported size, although a few large O. elongatus (>20 kg) were seen off Danger Island during August, 1977. Usually the lingcod is solitary in distribution. Density estimates at

Schooner Rock reached a maximum of $0.02/\text{M}^2$ (Tables 3 & 4); more were encountered at Danger island where densities ranged from 0 to $0.04/\text{M}^2$ (Tables 5-8). The average density of $0.006/\text{M}^2$ was identical in both locations.

Soft Bottom (exposed)

The soft bottom north of Schooner Rock consisted of coarse to finely packed sand. Ripple marks and small sand waves were prominent about 21.0 m below the sea surface. Small rocks were occasionally found in this habitat, especially in close proximity to the rocky reef.

Some of the dominant macroinvertebrates that were observed on the soft bottom in this location were tubicolous polychaetes, a sea pen (Ptilosarcus gurneyi), snails (Olivella baetica and Nassarius mendicus) and a crab (Cancer branneri).

The nearshore fish fauna was also common on the unconsolidated substrates. Most of these species were demersal forms which are adapted for this unique habitat. Among these were righteye flounders or flatfishes such as the yellowfin sole (Limanda aspera), starry flounder (Platichthys stellatus), rock sole (Lepidopsetta bilineata) and Pacific halibut (Hippoglossus stenolepis). Pacific sand lance (Ammodytes hexapterus) were also seen on this expanse of sand. Some large schools of A. hexapterus were observed in the water column along the edge of the reef, and other individuals buried themselves in the soft bottom. When frightened or disturbed, the sand lance usually darted out of the soft sediment and fled.

Lepidopsetta bilineata Ayres - Rock Sole

One of the most conspicuous flounders in the nearshore zone is the rock sole (Lepidopsettabilineata). Rock sole were abundant around Schooner Rock and most were seen on soft or unconsolidated substratum at shallow depths between 18 and 24 m. Frequently, this species was observed with Pacific halibut (Hippoglossus stenolepis) and starry flounder (Platichthys stellatus). Besides their occurrence in the ocean entrances of Prince William Sound, these fish range as far north as Port Valdez and inhabit estuaries, eelgrass meadows and protected embayments or fjords. Hart (1973) reported that rock sole move into shallow water during summer, and this seems to be the case in Prince William Sound.

The stomach contents of 9 L. bilineata, ranging in size from 25 to 40 cm, were examined for food items. Eight of the 9 specimens contained identifiable organisms in their stomachs. Fish eggs occurred in 3 of 8 specimens, and this category accounted for 13.6 percent of the food items (Table 14). Sand lance (Ammodytes hexapterus) were found in the stomachs of 2 rock sole collected at -23.0 m off the north side of Schooner Rock. Another L. bilineata, that was taken in Port Fidalgo when the herring were spawning along the beachlines, had a stomach that was 100 percent full of herring eggs and 6 Aglaja ?ocelligera, a shell-less cephalaspidean. Forrester and Thomson (1969) found that this small flatfish preyed upon shrimps, small crabs, polychaete worms, clam siphons, brittle stars and sand lance in the coastal waters of British Columbia.

Table 14

FOOD OF ROCK SOLE (*Lepidopsetta bilineata*)
FROM THE NORTHEASTERN GULF OF ALASKA (N=8)

<u>Food Items</u>	<u>Frequency of Occurrence</u>	<u>Number</u>	<u>Percentage of Total</u>
<u>Ammodytes hexapterus</u> (fish)	2/8	2	9.0
Gammaridean amphipods	1/8	2	9.0
<u>Olivella baetica</u> (snail)	1/8	1	4.5
<u>Aglaja ocelligera</u> (opisthobranch snail)	1/8	6	27.2
Polychaete (worms)	2/8	2	9.0
Caridean shrimps	1/8	1	4.5
Arenicolidae	2/8	2	9.0
Tellinidae (bi valve)	1/8	1	9.0
Unid. food items	2/8	2	9.0
Fish eggs (herring)	3/8	3	13.6

Hippoglossus stenolepis Schmidt - Pacific Halibut

Mature halibut are found in the shallow waters of Prince William Sound and the northern Gulf of Alaska predominantly during the months of May through September (Cordova fishermen, pers. comm.). This highly sought after species is routinely taken from near surface to depths in excess of 100 fathoms. The inshore fishing grounds are comprised of a variety of habitats ranging from subtidal kelp forests to protected embayments and exposed offshore reefs. Halibut occurred at both study sites during 1977. At Schooner Rock the fish were collected from the base of the reef out to a depth of -24 m. Most of the specimens were taken on a bottom that was composed of coarse sands and small rock (Figure 5). Halibut were also seen along the steeply sloped shores of Danger Island; here the bottom was dominated by boulders, exposed bedrock and deeply cut valleys with sand and shell debris. One large H. stenolepis (182 cm) was taken on hook and line while anchored on station above the 19 m depth contour. This huge fish was a female and it weighed in excess of 90 kg.

Food consisted of crabs, snails, octopus and brown algae (Table 15). The major prey species was Cancer branneri (crab); it occurred in 3 of 5 specimens, and comprised 53.8 percent of the total. One halibut (62 cm) had 5 Cancer branneri in its stomach. All of the crabs were swallowed whole, thus simplifying the identification process. The second major food item was the decorator crab (Pugettia gracilis); frequency of occurrence was 2/5, and this species accounted for 11.5 percent of the total number of food items obtained from these specimens. The occurrence of halibut preying on large crustacea such as dungeness, king and tanner crab was reported by Gray (1964) for samples obtained off Kodiak Island.

Table 15

FOOD OF PACIFIC HALIBUT (Hippoglossus stenolepis)
FROM THE NORTHEASTERN GULF OF ALASKA (N=5)

<u>Food items</u>	<u>Frequency of Occurrence</u>	<u>Number</u>	<u>Percentage of Total</u>
<u>Cancer branneri</u> (crab)	3/5	14	53.8
<u>Pugettia gracilis</u> (crab)	2/5	3	11.5
<u>Oregonia gracilis</u> (crab)	1/5	1	3.8
<u>Neptunea sp.</u> (snail)	1/5	1	3.8
<u>Octopus sp.</u> (octopus)	1/5	1	3.8
<u>Desmarestia aculeata</u> (brown algae)	1/5	1	3.8
Stones	1/5	5	19.2

Platichthys stellatus Pallas - Starry Flounder

Starry flounder are distributed from Santa Barbara, California to arctic Alaska and the Sea of Japan (Miller and Lea, 1972). In the northern Gulf of Alaska, P. stellatus has been collected as far north as Port Valdez. Common in the shallow waters of Prince William Sound from April through September; it frequents a variety of habitats ranging from ocean entrances to protected estuaries.

Seven specimens were collected in the nearshore zone during 1976-77; most were taken in northeastern Prince William Sound when the Pacific herring (Clupea harengus pallasii) were spawning in the vicinity of Port Fidalgo and Tatitlek Narrows. Six starry flounder ranged in size from 45.5 cm to 59.0 cm; all 6 flatfish had consumed herring eggs that were attached to seaweeds and seagrasses. The stomachs of these specimens were 80-100 percent full of herring eggs. Another starry flounder (52.5 cm) was collected on the soft bottom at the base of Schooner Rock. The diet consisted of clam siphons, brittle stars and a crab Cancer branneri (Table 16). Clemens and Wilby (1961) reported that the food of P. stellatus consists of crabs, shrimps, worms, clams, clam siphons, small mollusks and fish.

Table 16

FOOD OF STARRY FLOUNDER (Platichthys stellatus)
FROM THE NORTHEASTERN GULF OF ALASKA (N=7)

<u>Food Items</u>	<u>Frequency of Occurrence</u>	<u>Number</u>	<u>Percentage of Total</u>
Herring eggs (fish)	6/7	6*	35.2
Clam siphons	1/7	2	11.7
Brittle-stars (unidentified)	1/7	3	17.6
<u>Cancer branneri</u> (crab)	1/7	1	5.8
<u>Analipus japonicus</u> (brown algae)	2/7	2	11.7
<u>Zostera marina</u> (eelgrass)	2/7	2	11.7
<u>Desmarestia aculeata</u> (brown algae)	1/7	1	5.8

*hundreds of eggs were ingested by these fish

Macrophyte Assemblage (protected)

Within the protected confines of Prince William Sound there is an undetermined amount of macrophyte biomass. The marine plants form a conspicuous girdle along the beachlines of the Sound. Now and then the belt is broken or interrupted by conditions that are unfavorable or Preclude plant colonization and growth. The rocky or solid substratum generally provides most of the suitable habitat for seaweed germination and growth. Conversely, the soft or unconsolidated silty clays and sands, from about -9.0 m to MLLW, seem to offer optimal substrate for eelgrass (Zostera marina). Most of the eelgrass has been found near the mouths of creeks, or in quite estuaries and saltwater lagoons. The eelgrass stands of Prince William Sound vary in areal dimension from small patches to meadows covering several square acres. These protected habitats differ from those on the outer coast in that the sea floor and vegetative undergrowth is usually dusted by a thin layer of silt.

The eelgrass meadows and protected seaweed beds were typically high in the number of fish species. However, maximum species richness and abundance was not sustained on a year-round basis, but was instead highly seasonal, since the highest counts were obtained from about April to October. The influx of fishes into the nearshore zone is usually centered around the activities of commercially valuable species such as the pacific herring, chum salmon, red salmon, pink and silver salmon. The flurry of activity is intense, when these and other pelagic schooling species move into the shallow sublittoral zone. In addition to the adult fishes, newly emergent fry and juvenile stages of an undetermined number

of fish species pass **their** early developmental periods **within** the protected confines of the macrophyte band. Schools of juvenile herring, tube-snout, sand lance, salmon and walleye pollock, were frequently seen hovering around the meadows of **benthic** vegetation. Conspicuous bottom fishes of the assemblage consisted of pacific tomcod, white-spotted greenling, flatfishes, great sculpin and arctic shanny. With the approach of winter, the macrophyte canopies **begin** to deteriorate, water temperatures decline sharply and the transient species migrate out of the shallow water zone. The habitat now has the appearance of **being almost devoid of** fish life, except for the **demersal** species that **remain** under cover.

There is sufficient evidence of trophic interaction between fishes and their prey species in the nearshore zone to **present** a very qualitative food web (Figure 6). It should be pointed out that all of the habitats and species investigated have been combined in this **single** diagram.

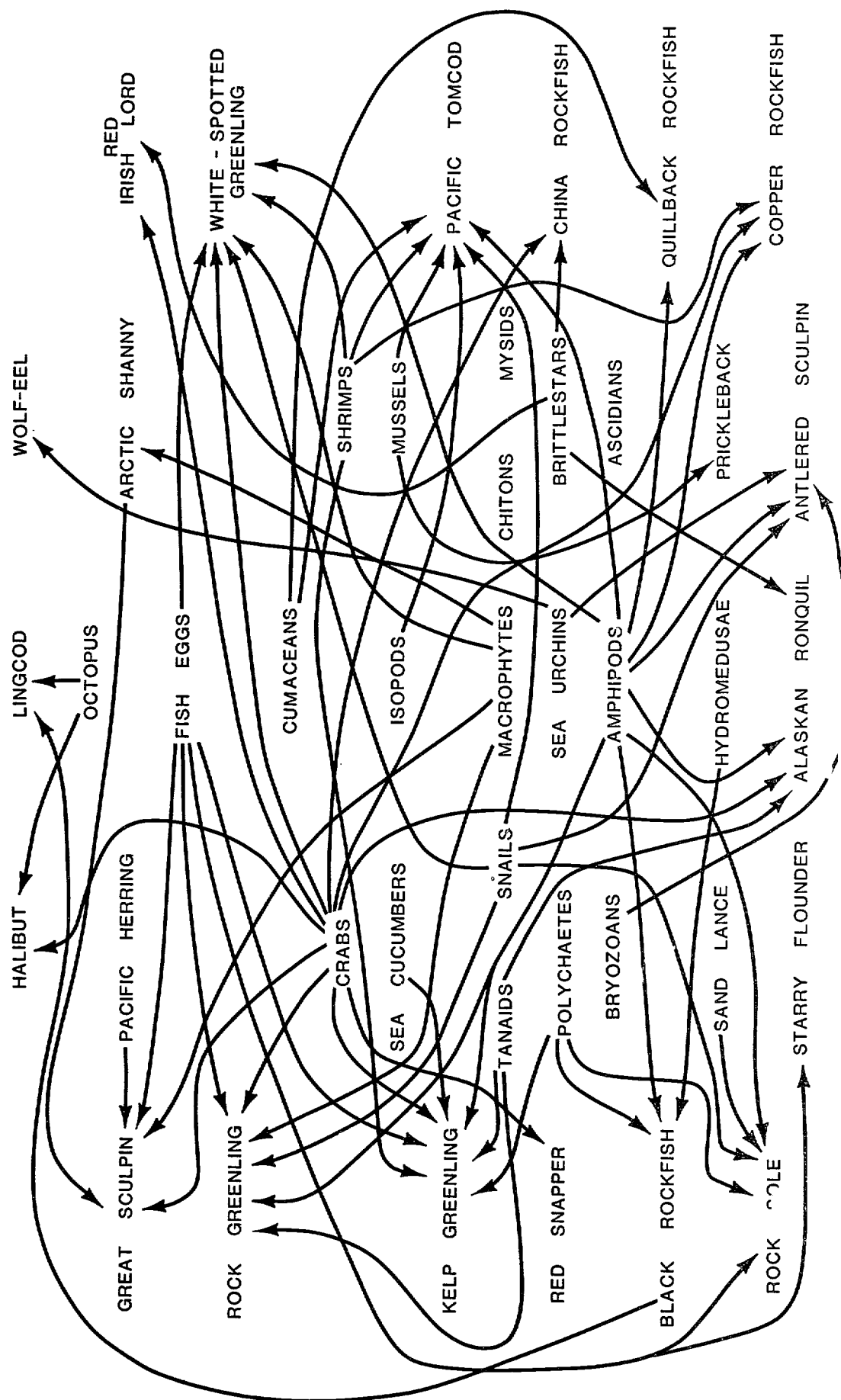


FIGURE 2

TROPHIC INTERACTION AMONG NEARSHORE FISHERIES AND THEIR PREY SPECIES IN THE NORTHEASTERN GULF OF ALASKA

Microgadus proximus Girard - Pacific Tomcod

The Pacific **tomcod** is one of the most ubiquitous species in the shallow waters of the northeastern Gulf of Alaska. **It** has been collected in a variety of habitats ranging from boat harbors and protected **eelgrass** meadows to exposed outer coast kelp beds. **Young** tomcod were frequently observed hovering in bull kelp forests and seaweed **canopies** off the southwest end of **Latouche** Point and Danger Island. Juvenile **pollock** are known to associate with the jellyfish **Cyanea** (Van Hyning and Cooney, 1974), and young tomcod possibly **also** accompany these jellyfishes which drift in dense aggregations. During summer months, the **Cyanea** are often accompanied by immature gadids **which** swim under the bell and among the tentacles. Hart (1973) reports that mature tomcod reach a maximum length of 30.5 cm, however one individual that was collected by us at Zaikof Point was 31.6 cm in **total** length.

Pacific tomcod occurred in small to moderate size schools of up to around **100 individuals**. The densest concentrations were observed along the edges of **eelgrass** meadows. Active during daylight hours, particularly when they are foraging **along** the bottom in the shallow **subtidal** zone. It was the most commonly captured fish in the experimental **gillnet sampling** at Zaikof Point, and accounted for 46 percent of the total catch (Table 17).

Twenty-seven individuals (9.0 - 31.6 cm) were collected from Prince William Sound, and of these, **all** 27 contained food **items** (Table 18). Gammaridean amphipods were the major prey in terms of numerical dominance, and this group accounted for 47.7 percent of the **ingested** prey. Three of

Table 17

EXPERIMENTAL GILLNET FISHING AT **ZAIKOF POINT***
 12 HOUR FISHING TIME - 1800 HR. (8/16/77) TO 0600 HR. (8/17/77)

<u>Species</u>	<u>Number</u>	<u>Percentage of Total Catch</u>
<u>Oncorhynchus gorbuscha</u> (Pink Salmon)	9	24.3
<u>Hexagrammos decagrammus</u> (Kelp Greenling)	1	2.7
<u>Hexagrammos stelleri</u> (Whitespotted Greenling)	8	21.6
<u>Hexagrammos lagocephalus</u> Rock Greenling	1	2.7
<u>Sebastes sp.</u> (Juvenile Rockfish)	1	2.7
<u>Microgadus proximus</u> (Pacific Tomcod)	17	45.9
TOTAL	37	100

*Edge of Bull Kelp Nereocystis bed off north end of Point

Table 18

FOOD OF PACIFIC TOMCOD (*Microgadus proximus*)
FROM THE NORTHEASTERN GULF OF ALASKA (N=27)

<u>Food Items</u>	<u>Frequency of occurrence</u>	<u>Number</u>	<u>Percentage of Total</u>
Gammaridean amphipods	10/27	204	47.7
Caprellid amphipods	1/27	3	0.7
Caridean shrimps	5/27	11	2.5
Brachyuran juveniles	2/27	8	1.8
Tanaids	1/27	1	0.2
Cummaceans	4/27	4	0.9
Polychaetes	3/27	3	0.7
<i>Musculus</i> spp. (mussel)	3/27	91	21.3
<i>Olivella baetica</i> (snail)	3/27	28	6.5
<i>Idothea</i> spp. (isopod)	3/27	6	1.4
<i>Ammodytes hexapterus</i> (fish)	2/27	2	0.4
<i>Gnorimosphaeroma oregonensis</i> (isopod)	9/27	45	10.5
? <i>Homalopoma</i> sp. (snail)	1/27	4	0.9
<i>Cucumaria</i> sp. (sea cucumber)	1/27	1	0.2
<i>Telmessus cheiragonus</i> (crab)	1/27	1	0.2
Fishes	3/27	3	0.7
<i>Lacuna</i> spp. (snail)	1/27	4	0.9
<i>Pugettia gracilis</i> (crab)	1/27	1	0.2
<i>Pagurus</i> spp. (hermit crab)	1/27	2	0.4
<i>Zostera marina</i> (eelgrass)	2/27	2	0.4
Phaeophyta (brown algae)	2/27	1	0.2
Other	2/27	2	0.4

the M. proximus that were collected from an **eelgrass** meadow in Sheep Bay (Figure 1) had a combined total "of 91 mussels (Musculus sp.) in their stomachs. These prey accounted for 21.3 percent of the total number of identifiable food items. A **small** sphaeromatid **isopod**, Gnori mosphaeroma oregonensis occurred in 9 of the 27 specimens, and this represented 10.5 percent of the prey for those fish collected during 1974-77. **Other** important food items were snails, caridean **shrimps**, **juvenile brachyuran crabs** and small fishes such as Ammodytes hexapterus.

Hexagrammos stelleri Tilesius - Whitespotted Greenling

The whitespotted greenling is distributed along the shores of Prince William Sound from Port Valdez to Hinchinbrook Entrance. However, unlike two of its congeners (H. lagocephalus and H. decagrammus) which seem to thrive in outer coast or exposed habitats, the whitespotted is more typically found in protected habitats which rarely are influenced by deep sea swells. It was commonly seen in association with eelgrass (Zostera marina) meadows and beds of seaweeds. Occasionally it was seen swimming with small schools of pacific tomcod (Microgadus proximus), however during daylight hours it was most often solitary in distribution. It reputedly reaches a size of 41 cm, although we have seen some individuals that possibly could have exceeded this total body length.

During most of the calendar year, mature H. stelleri are light brown to yellowish green in color, with white spots scattered on the head and body. There is also another color pattern in males which identifies a nest-guarding individual from other members of the species. In these individuals the white spots are usually replaced by grey ones, and the body coloration is more of a uniform golden-brown. Nest guarding individuals were collected in northeastern Prince William Sound on September 28, 1977. Seven individuals ($\bar{x} = 24.4$ cm) were captured from nests, and all of these were males. The eggs were attached to decumbent fleshy seaweeds, hydroids and articulated corallines. Most of the egg clusters were 5.0 to 10.0 cm in diameter and occurred in shallow water above -10 meters.

Hexagrammos stelleri was not encountered in the subtidal band

transects at either Schooner Rock or Danger Island, however, individuals were collected off **Latouche** Point (Figure 2) and along the north side of **Zaikof** Point (Figure 3). In addition to these direct observations, H. stelleri was the third most abundant species captured by **gillnet** sampling at **Zaikof** Point and this represented 21 percent of the total (Table 17).

Twenty **specimens** (10.5 - 31.0 **cm**) were collected from the shallow subtidal waters of the **Sound**, and the stomachs of all of these contained identifiable food items (Table 19). Although these fish contained **zooplankters**, most of the **prey organisms** were **probably** **plucked** from attached vegetation and solid substrata. **Gammaridean amphipods** accounted for 70.9 percent of the total food items. Other **principal foods** were small gastropod such as Margarities spp. and Lacuna variegata, **caridean** shrimps, **brachyuran** crabs, isopods, mussels, **caprellid amphipods** and fish eggs. Most of these prey were associated with macrophytes, which were also ingested along with the animal material. Plant fragments and detritus occurred in 9 of 20 specimens.

Table 19

FOOD OF WHITESPOTTED GREENLING (Hexagrammos stelleri)
FROM THE NORTHEASTERN GULF OF ALASKA (N=20)

<u>Food Items</u>	<u>Frequency of Occurrence</u>	<u>Number</u>	<u>Percentage of Total</u>
Gammaridean amphipods	14/20	183	70.9
Caprellid amphipods	2/20	2	1.2
Caridean shrimps	5/20	8	3.1
Brachyuran juveniles	2/20	4	1.5
<u>Pugettia gracilis</u> (crab)	4/20	6	2.3
<u>Idothea</u> spp. (isopod)	2/20	3	1.1
<u>Margarites</u> spp. (snail)	3/20	16	6.2
<u>Lacuna variegata</u> (snail)	2/20	5	1.9
<u>Mytilus edulis</u> (mussel)	2/20	6	2.3
<u>Gnorimosphaeroma oregonensis</u> (isopod)	1/20	1	0.3
Polychaetes	1/20	1	0.3
Fish eggs	4/20	4	1.5
<u>Telmessus cheiragonus</u> (crab)	1/20	1	0.3
<u>Pandalus danae</u> (shrimp)	1/20	1	0.3
<u>Nassarius meandicus</u> (snail)	1 /20	1	0.3
<u>Cancer oregonensis</u> (crab)	1/20	1	0.3
<u>Ammodytes hexapterus</u> (fish)	1 /20	1	0.3
<u>Lophopanopeus bellus</u> (crab)	1/20	1	0.3
<u>Hiatella arctica</u> (bivalve)	1/20	1	(-).3
<u>Zostera marina</u> (eelgrass)	3/20	3	1.1
Rhodophyta (red algae)	6/20	6	2.3
Detritus	2/20	2	0.7
Polyplacophora (chiton)	1 /20	1	0.3

Enophrys diceraus Pallas - Antlered Sculpin

The genus Enophrys is represented by at least 3 possible species in the Gulf of Alaska - E. bison, E. diceraus and possibly E. lucasi (Sandercock and Wilimovsky, 1968). The status of E. lucasi is still in doubt since it may be shown to be a deep water sibling of E. diceraus.

The antlered **sculpin** is widely distributed in Prince William Sound, however its occurrence in the exposed reaches of the northern Gulf is poorly understood. Most of the antlered **sculpin** were seen in protected embayments and shallow water kelp beds. Four specimens were captured during late spring and summer of 1977. One of the E. diceraus (22.0 cm) that was collected in Galena Bay on April 7, 1977 had eaten 4 green sea urchins (Strongylocentrotus droebachiensis), 5 limpets (Notoacmaea spp.) and 7 hermit crabs (Pagurus sp.). Limpets made up 35.4 percent of the diet of these **sculpin**, other important food items were juvenile **brachyuran** crabs and **gammarid** amphipods (Table 20). Enophrys is a generalist, and it forages on sedentary or slow moving macroinvertebrates that typically inhabit **macrophyte** communities.

Table 20

FOOD OF ANTLERED SCULPIN (Enophrys diceraus)
FROM THE NORTHEASTERN GULF OF ALASKA (N=4)

<u>Food Items</u>	<u>Frequency of Occurrence</u>	<u>Number</u>	<u>Percentage of Total</u>
<u>Notoacmaea</u> spp. (limpet)	2/4	11	35.4
<u>Strongylocentrotus droebachiensis</u> (sea urchin)	3/4	6	19.3
<u>Pagurus</u> spp. (hermit crab)	2/4	8	25.8
<u>Crepidula</u> sp. (snail)	1/4	1	3.2
<u>Microporina borealis</u> (bryozoan)	1/4	1	3.2
Brachyuran juveniles	1/4	2	6.4
Gammaridean amphipods	1/4	2	6.4

Myoxocephalus - Great Sculpin

The taxonomy and arrangement of the genus Myoxocephalus is apparently in need of revision. There are reports of at least 2 species: M. polyacanthocephalus and M. scorpius from the Gulf of Alaska (Quast and Hall, 1972). Because of these taxonomic problems our observations on foraging behavior are directed at the genus Myoxocephalus. This large sculpin has been seen as far north as Port Valdez; it commonly inhabits protected embayments, eelgrass meadows and kelp beds. Vertical distribution is unknown, however, a large aggregation of mature Myoxocephalus was observed around the sunken fishing vessel Saint Peter, approximately 52 meters below the sea surface.

Ten great sculpin were collected in northeastern Prince William Sound during spring, 1977. These fish ranged in size from 22.5 to 40.0 cm. All of the specimens were taken in the shallow subtidal zone, on a bottom that was dominated by seaweeds and seagrasses. Brachyuran crabs accounted for a combined total of 42.7 percent of the food items (Table 21). The major prey species was the pacific herring (Clupea harengus pallasii); it occurred in 5 out of 10 samples and comprised 25.0 percent of the total. One of the Myoxocephalus ingested 3 adult herrings (22.0 - 24.0 cm), 1 hermit crab (Elassochirus gilli) and eelgrass leaves. Prior to the her-ring spawning activities the sculpin preyed on adult herring, however after egg deposition the Myoxocephalus switched to eating the herrings' eggs that were attached to macrophytes.

Table 21

FOOD OF GREAT SCULPIN (*Myoxocephalus* spp.)
FROM THE NORTHEASTERN GULF OF ALASKA (N=10)

<u>Food Items</u>	<u>Frequency of Occurrence</u>	<u>Number</u>	<u>Percentage of Total</u>
<u>Cancer oregonensis</u> (crab)	1/10	2	7.1
<u>Pugettia gracilis</u> (crab)	2/10	3	10.7
<u>Telmessus cheiragonus</u> (crab)	4/10	6	21.4
<u>Pagurus spp.</u> (hermit crab)	1/10	2	7.1
<u>Elassochirus gilli</u> (hermit crab)	1/10	1	3.5
<u>Chionoecetes bairdi</u> (crab)	1/10	1	3.5
<u>Stichaeus punctatus</u> (fish)	1/10	1	3.5
<u>Clupea harengus pallasii</u> (fish)	5/10	7	25.0
Fish eggs (herring)	1/10	1	3.5
<u>Zostera marina</u> (eelgrass)	2/10	2	7.1
<u>Rhodophyta</u> (red algae)	2/10	2	7.1

SUPWARY

- 1.) The nearshore fish assemblages of the northern **Gulf** of Alaska were represented **by** at least 44 fish **species** during daylight hours. The shallow water habitats **investigated during 1974-77, harbored distinct** assemblages **despite** similarities in depth and distance from the shoreline.
- 2.) There was a pronounced oscillation in the composition of these fish assemblages from season to season. During summer months the **protected** habitats were dominated by pelagic schooling species, e.g. herring, salmon and sand lance, whereas the exposed habitats were dominated **by demersal** reef fishes such as black **rockfish, greenling and lingcod**. Abundance and species richness remained high into early fall. However, by winter the **fishes** were a minor component of **the** inshore system within the protected confines of **Prince William** Sound. These differences were less **noticable** on the outer coast, however, some changes in vertical distribution and abundance were **apparent** in the **subtidal** kelp forests.
- 3.) The **subtidal** boulder fields below the **macrophyte** belt were **key** habitats, and characteristically yielded the highest estimates of fish abundance and biomass compared to other areas on the exposed coastline. Preliminary observations indicate **that** the substrate type, and degree of oceanic circulation are prime factors in determining the structure and appearance of the fish community.

- 4.) The opportunistic foraging behavior of the bottom fishes was apparent from the wide array of prey that were taken as food. Major **prey** included gammaridean amphipods, brachyuran crabs, **isopods**, snails, mussels, **caridean** shrimps and brittle stars.
- 5.) These limited observations indicate that the nearshore zone **provides** refuge and **feeding** grounds for countless numbers of juvenile fish. It also houses or attracts a number of **large** predatory reef fishes such as the red **snapper**, **lingcod** and halibut, and more transient pelagic species like the pacific salmon. Most certainly these species are functional dominants in these assemblages, and as such **play** vital roles in the overall ecosystem.

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